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TECHNICAL REPORT
ECOM-00240-1, VOL. II

# LIGHT TRANSPORT IN THE ATMOSPHERE

## Volume II: Machine Codes for Calculation of Aerosol Scattering and Absorption Coefficients

ANNUAL REPORT
1 August 1965 to 31 August 1966

*By*

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SEPTEMBER 1966

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND • FORT MONMOUTH, N.J.

CONTRACT DA28-043 AMC-00240(E)

RADIATION RESEARCH ASSOCIATES, INC.
Fort Worth, Texas

TECHNICAL REPORT ECOM-00240-1, VOL. II September 1966

RRA-T63-2

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# ABSTRACT

This is the second of three volumes. Volumes I and III contain other aspects of the study: descriptions of the LITE codes and their application to the analysis of experimental data. Two machine programs were developed for use in computing microscopic and macroscopic cross sections for light scattering and absorption by spherical-homogeneous aerosol particles with a complex index of refraction. The first of these programs computes microscopic cross section data by use of the Mie theory. The second program integrates the microscopic cross section data over aerosol particle size distributions to produce macroscopic cross section data. These codes have been written in ALGOL for the Burroughs B-5500 computer and in FORTRAN-IV for other computers.

Calculations obtained from these codes have been compared with data reported by other investigators in order to verify their accuracy. A sizable quantity of aerosol cross section data has been generated for several aerosol particle size distributions and the results are presented in this volume. In addition, a description of the calculational methods and instructions for utilization of the two codes on the B-5500 computer are given to aid those who wish to utilize the codes.

## FOREWORD

The authors wish to express their appreciation to Henrietta Hendrickson and Hemma Francis of the Oak Ridge National Laboratory computing facility who aided in the checkout and running of problems on the FORTRAN versions of the RRA-42 and RRA-45 codes. They also wish to acknowledge the assistance of Leon Leskowitz of the U. S. Army Electronics Laboratory, Fort Monmouth, New Jersey, for his assistance in translating the FORTRAN codes to the ALGOL language and his many helpful suggestions during the checkout of the ALGOL versions. The work described in this report was carried out under the technical monitorship of R. W. Fenn of the Air Force Cambridge Research Laboratories, Bedford, Massachusetts, and I. Cantor of the Atmospheric Science Laboratory, USAECOM, Fort Monmouth, New Jersey.

## PREFACE

During the period 1 August 1965 to 31 August 1966 Monte Carlo studies were performed to determine light transport in the atmosphere under various environmental conditions. These studies consisted of: 1) correlation analysis of light transport from a point isotropic source and a plane parallel source to determine the comparability of solar light transmission data and transmission properties for thermal radiation from nuclear weapons, 2) development of machine codes for calculation of phase functions and scattering and absorption coefficients for spherical-homogenous aerosol particles with a complex index of refraction, 3) an analysis of experimental field data on light transmission, 4) parameter studies to determine the specific influence of ground and cloud albedo, cloud height, and aerosol number density and particle size distribution on the transport of light in the atmosphere, 5) modifications to the LITE codes to increase their application to a wider range of atmospheric transport problems and 6) the development of a machine program for use in converting the scattered intensities computed by the LITE codes for a given ground albedo to data giving scattered intensities and scattered fluxes for other ground albedos. The results of these studies are presented in this report, which is divided into three volumes. The first volume describes the results of items 1, 3, and 4 outlined above. The second volume describes the machine programs developed for use in calculation of aerosol cross sections. The third volume contains utilization instructions for the modified versions of the LITE codes and for the code development to convert the LITE results to data giving scattered intensities and fluxes for other ground albedos.

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# I. INTRODUCTION

In any problem concerned with the transport of light in the atmosphere, the nature of scattering and absorption of light by aerosol particles is an important consideration. This is especially true when the effects of varying atmospheric conditions are being studied, since the concentration, size distribution, and refractive index of the aerosol content of the atmosphere may contribute larger variations to the scattering properties of the atmosphere than other perturbing factors. The object of the work described in this report was to develop a method of calculating aerosol cross section data in the format required by the LITE codes (Ref. 1). The LITE codes use Monte Carlo techniques to evaluate the transport of light in a plane atmosphere.

In most cases aerosol particles may be approximated by dielectric spheres of varying size and refractive index, whether they are found in continental hazes, smoke hazes, water hazes, fogs or clouds. For such spheres, the scattering of light can be rigorously described by the application of pure electrodynamics and is usually termed Mie scattering. The application of the exact Mie theory to scattering problems has not been widespread until recent years, due to the length and complexity of the calculations involved. However, with the present accessibility of high-speed electronic computers, this difficulty no longer exists and computations may be performed without relying upon approximations and extrapolations from limiting cases.

After microscopic Mie cross section and scattering phase function data have been obtained for spheres of particular sizes and refractive

indices, the nature of the scattering of light with a given wave length by aerosol concentrations composed of particles of diverse radii can be computed by integrating the microscopic data over a particle size distribution chosen to represent the true aerosol size distribution for particular atmospheric conditions.

Two computer programs, RRA-42 and RRA-45, have been developed for use in computing aerosol scattering and absorption data for input to the LITE codes. The first code calculates pertinent microscopic scattering and absorption data based upon the Mie theory, and the other integrates this data over realistic aerosol concentrations. These codes have the capability of producing data of more general interest, since the results of the calculations may be useful in any problem dealing with the scattering of electromagnetic radiation by particles which may be approximated by spheres suspended in a homogeneous medium.

The theory used in the Mie scattering calculations is treated fully by Van de Hulst (Ref. 2). Section II, therefore, presents only the basic relationships, without description of their theoretical derivations. The computational procedure used by the codes, complete instructions for their utilization, and selected calculations using the procedures are also contained in the remainder of this report.

## II. CALCULATIONAL PROCEDURES

The following two sections describe the equations used in RRA-42 to compute scattering and absorption cross section data based on Mie theory and in RRA-45 to integrate the Mie data over arbitrary aerosol particle size distributions to obtain macroscopic aerosol cross section data.

### 2.1 Microscopic Mie Scattering

Consider light with wave length $\lambda$ propagating in the region of a dielectric sphere of radius r and complex index of refraction $m = n - in'$. The resulting scattered radiation field is defined by the Mie theory to have vector components of the electric field perpendicular to the direction of propagation with magnitudes

$$S_1(r,\lambda,m,\theta) = \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} \left[a_n\pi_n + b_n\tau_n\right] , \tag{1}$$

and

$$S_2(r,\lambda,m,\theta) = \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} \left[b_n\pi_n + a_n\tau_n\right] , \tag{2}$$

where $S_1$ and $S_2$ are the complex amplitude functions of the scattered wave. The quantities $a_n$ and $b_n$ are the Mie coefficients and $\pi_n$ and $\tau_n$ are angular dependent functions of Legendre polynomials. The explicit dependence of these and following relationships upon a specific pair of r and $\lambda$ values may be removed by defining the variable x, the size parameter, by

$$x = 2\pi r/\lambda . \tag{3}$$

The Mie coefficients may then be written in the form given by Van de Hulst:

$$a_n = \frac{\psi_n'(mx)\psi_n(x) - m\psi_n(mx)\psi_n'(x)}{\psi_n'(mx)\zeta_n(x) - m\psi_n(mx)\zeta_n'(x)} , \tag{4}$$

and

$$b_n = \frac{m\psi'_n(mx)\psi_n(x) - \psi_n(mx)\psi'_n(x)}{m\psi'_n(mx)\zeta_n(x) - \psi_n(mx)\zeta'_n(x)} \quad (5)$$

with $\psi_n(x) = xj_n(x)$

and $\zeta_n(x) = xh_n^{(2)}(x)$ ,

where $j_n(x)$ are the spherical Bessel functions, $h_n^{(2)}(x)$ are spherical Hankel functions of the second kind, and the primes indicate differentiation with respect to the argument. The angle-dependent coefficients, $\pi_n$ and $\tau_n$, are written

$$\pi_n = \frac{\delta}{\delta\cos\theta} P_n(\cos\theta)$$

and

$$\tau_n = \pi_n\cos\theta - (\sin^2\theta) \frac{\delta\pi_n}{\delta\cos\theta} ,$$

where $P_n(\cos\theta)$ are Legendre polynomials and the symbol $\delta$ indicates partial differentiation.

It can be seen that the amplitude functions may be computed to arbitrary accuracy by evaluating the convergent series in n to the required number of terms. However, the Mie coefficients are difficult to evaluate in the form shown in Equations 4 and 5. The calculations may be simplified by expressing $a_n$ and $b_n$ as functions involving only ordinary Bessel functions of order $\pm n\pm\frac{1}{2}$, $J_{\pm n\pm\frac{1}{2}}(z)$, and their derivatives, where $z = x$ or $z = mx$. This may be done by the application of the following identities:

$$j_n(z) = \left(\frac{\pi}{2z}\right)^{\frac{1}{2}} J_{n+\frac{1}{2}}(z) ,$$

$$h_n^{(2)}(z) = \left(\frac{\pi}{2z}\right)^{\frac{1}{2}} \left[J_{n+\frac{1}{2}}(z) - i\,N_{n+\frac{1}{2}}(z)\right] \quad ,$$

$$N_{n+\frac{1}{2}}(z) = \left(\frac{2z}{\pi}\right)^{\frac{1}{2}} n_n(z) \quad ,$$

and

$$n_n(z) = (-1)^{n+1}\left(\frac{\pi}{2z}\right)^{\frac{1}{2}} J_{-n-\frac{1}{2}}(z).$$

After performing these substitutions and taking the required derivatives, Equations 4 and 5 may be algebraically altered and written in a form previously reported by Deirmendjian (Ref. 3);

$$a_n = \frac{\left[\frac{A_n}{m} + \frac{n}{x}\right] J_{n+\frac{1}{2}}(x) - J_{n-\frac{1}{2}}(x)}{\left[\frac{A_n}{m} + \frac{n}{x}\right] \left[J_{n+\frac{1}{2}}(x) + i(-1)^n J_{-n-\frac{1}{2}}(x)\right] - J_{n-\frac{1}{2}}(x) + i(-1)^n J_{-n+\frac{1}{2}}(x)} \quad , \qquad (6)$$

and

$$b_n = \frac{\left[mA_n + \frac{n}{x}\right] J_{n+\frac{1}{2}}(x) - J_{n-\frac{1}{2}}(x)}{\left[mA_n + \frac{n}{x}\right] \left[J_{n+\frac{1}{2}}(x) + i(-1)^n J_{-n-\frac{1}{2}}(x)\right] - J_{n-\frac{1}{2}}(x) + i(-1)^n J_{-n+\frac{1}{2}}(x)} \quad , \qquad (7)$$

where

$$A_n = A_n(mx) = -\frac{n}{mx} + \frac{J_{n-\frac{1}{2}}(mx)}{J_{n+\frac{1}{2}}(mx)} \quad .$$

The form of these expressions for $a_n$ and $b_n$ is particularly convenient since the portion of the coefficients containing Bessel functions of complex argument is restricted to the $A_n$ terms, which may be calculated separately. This is done through the simple recursion formula

$$A_n(mx) = -\frac{n}{mx} + \frac{1}{\frac{n}{mx} - A_{n-1}(mx)} \quad ,$$

where

$$A_o(mx) = \frac{J_{-\frac{1}{2}}(mx)}{J_{+\frac{1}{2}}(mx)} = \cot\,(mx) \quad .$$

Again capitalizing upon the affinity of Bessel functions for recursion formulae, Equations 6 and 7 may be written

$$a_n = \frac{[\frac{A_n}{m} + \frac{n}{x}]\mathrm{Re}(w_n) - \mathrm{Re}(w_{n-1})}{[\frac{A_n}{m} + \frac{n}{x}]w_n - w_{n-1}} \tag{8}$$

and

$$b_n = \frac{[mA_n + \frac{n}{x}]\mathrm{Re}(w_n) - \mathrm{Re}(w_{n-1})}{[mA_n + \frac{n}{x}]w_n - w_{n-1}} \quad , \tag{9}$$

where

$$w_n(x) = \frac{2n-1}{x} w_{n-1} - w_{n-2} \quad ,$$

and

$$w_o(x) = \sin x + i\cos x \quad ,$$

$$w_1(x) = \cos x - i\sin x \quad .$$

Thus $a_n$ and $b_n$ may be computed by evaluating $A_n$ and $w_n$ separately, with the only preliminary computations being cosx, sinx and cot mx.

Likewise, the angular-dependent functions, $\pi_n$ and $\tau_n$, may be determined by recursion formulae with the relations

$$\pi_n(\theta) = (\frac{2n-1}{n-1})\pi_{n-1}(\theta)\cos\theta - (\frac{n}{n-1})\pi_{n-2}(\theta) \quad ,$$

and

$$\tau_n(\theta) = \cos\theta[\pi_n(\theta) - \pi_{n-2}(\theta)] - (2n-1)\sin^2\theta[\pi_{n-1}(\theta)] + \tau_{n-2}(\theta) \quad ,$$

where

$$\pi_o(\theta) = 0 \qquad \tau_o(\theta) = 0$$

$$\pi_1(\theta) = 1 \qquad \tau_1(\theta) = \cos\theta$$

$$\pi_2(\theta) = 3\cos \qquad \tau_2(\theta) = 3(1 - 2\sin^2\theta) \quad .$$

The extinction and scattering cross sections for light of wave length $\lambda$ incident on a sphere of radius r are calculated by evaluating the convergent series

$$\sigma_{ext}(\lambda,r,m) = \frac{\lambda^2}{2\pi} \sum_{n=1}^{\infty} (2n+1)\mathrm{Re}(a_n + b_n) \tag{10}$$

and

$$\sigma_{sc}(\lambda,r,m) = \frac{\lambda^2}{2\pi} \sum_{n=1}^{\infty} (2n+1)\ (|a_n|^2 + |b_n|^2) \quad . \tag{11}$$

Explicit dependence upon a particular pair of r and $\lambda$ values may be eliminated by defining efficiency factors, $Q_{ext}$ and $Q_{sc}$, by

$$Q_{ext}(x,m) = \sigma_{ext}(r,\lambda,m)/\pi r^2$$

and

$$Q_{sc}(x,m) = \sigma_{sc}(r,\lambda,m)/\pi r^2 \quad ,$$

or

$$Q_{ext}(x,m) = \frac{2}{x^2} \sum_{n=1}^{\infty} (2n+1)\mathrm{Re}(a_n + b_n) \tag{12}$$

and

$$Q_{sc}(x,m) = \frac{2}{x^2} \sum_{n=1}^{\infty} (2n+1)\ (|a_n|^2 + |b_n|^2) \quad . \tag{13}$$

In order to fully describe the scattered radiation, the following four intensity functions must also be calculated:

$$i_1(x,m,\theta) = |S_1|^2 \quad , \tag{14}$$

$$i_2(x,m,\theta) = |S_2|^2 \quad , \tag{15}$$

$$i_3(x,m,\theta) = \mathrm{Re}(S_1 S_2{}^*) \quad , \tag{16}$$

and

$$i_4(x,m,\theta) = -\mathrm{Im}(S_1 S_2{}^*) \quad , \tag{17}$$

where the * indicates the complex conjugate. Since $S_1$ and $S_2$, defined in Equations 1 and 2, are the magnitude of the electric amplitude perpendicular and parallel, respectively, to the plane of scattering, the values $i_1$ and $i_2$ are proportional to the intensity of the light scattered per steradian, at some particular scattering angle, perpendicular and parallel to the plane of scattering. The quantities $i_3$ and $i_4$ are related to the Stokes' parameters defining the ellipticity and plane of polarization of the scattered light.

At a point in the radiation region of the scattered field, assuming azimuthal symmetry, the intensity of the scattered light is given by

$$I = \frac{F(\theta)}{k^2 R^2} I_o$$

where $I_o$ is the intensity of the incident radiation, $F(\theta)$ is a function of direction only, $k = 2\pi/\lambda$, and R is here the distance from the scattering center. For incident light polarized perpendicularly to the plane of scattering

$$F(\theta) = i_1 \quad ; \tag{18}$$

for parallel polarization

$$F(\theta) = i_2 \quad ; \tag{19}$$

and for natural light

$$F(\theta) = \frac{i_1 + i_2}{2} \quad . \tag{20}$$

In general, the scattering has a polarizing effect upon the incident light, independent of the original state of polarization. The degree of polarization of the scattered light is defined to be

$$P(\theta) = \frac{i_1 - i_2}{i_1 + i_2} \quad . \qquad (21)$$

A computer procedure, RRA-42, was written for the calculation of the microscopic Mie parametric data discussed above. The quantities computed by the code for a choice of x and m are the extinction efficiency (Equation 12), the scattering efficiency (Equation 13), $i_1$, $i_2$, $i_3$, and $i_4$ (Equations 14-17), $\frac{i_1 + i_2}{2}$, and the polarization (Equation 21). The values used in the calculations, $a_n$, $b_n$, $S_1$ and $S_2$ may also be printed out by the code. A discussion of some of the calculations performed using this code is given in Section III. A program listing, sample input and output data, and utilization instructions are presented in Section IV.

2.2 Integration over Aerosol Size Distributions

As stated previously, scattering of light in the atmosphere is effected by aerosol concentrations containing particles of various radii. To obtain the volume scattering function and the macroscopic scattering, absorption, and extinction cross sections for a given aerosol particle size distribution it will be necessary to integrate the microscopic scattering data given by RRA-42 for a given index of refraction over the aerosol size distribution.

Consider a medium containing N particles per $cm^3$ with the size distribution of the particles characterized by the function n(r) such that

$$N = \int_{r_{min}}^{r_{max}} n(r)dr \quad , \qquad (22)$$

where $r_{min}$ and $r_{max}$ are the minimum and maximum radii in the particle concentration. The volume scattering cross section is thus obtained by the expression

$$A_{sc}(m,\lambda) = \int_{r_{min}}^{r_{max}} \sigma_{sc}(m,\lambda,r)n(r)dr \quad , \tag{23}$$

where $A_{sc}(m,\lambda)$ is the volume scattering cross section (or attenuation coefficient), $\sigma_{sc}(m,\lambda,r)$ are the microscopic cross sections defined in Equation 11, and n(r) is the size distribution function. Since the computer program RRA-42 calculates all of the microscopic parameters as a function of the size parameter, x = kr, Equation 23 may be written in terms of the efficiency factors defined in Equation 13 as

$$A_{sc}(m,\lambda) = \int_{r_{min}}^{r_{max}} \pi r^2 \; Q_{sc}(m,r/\lambda)n(r)dr \quad . \tag{24}$$

Likewise the volume extinction cross section is written

$$A_{ext}(m,\lambda) = \int_{r_{min}}^{r_{max}} \pi r^2 \; Q_{ext}(m,r/\lambda)n(r)dr \quad . \tag{25}$$

The differential scattering cross section for photons is given by

$$\frac{d\sigma}{d\omega}(\theta) = F(\theta)/k^2 \quad ,$$

since

$$\sigma_{s} = \frac{1}{k^2} \int_{\substack{\text{solid}\\ \text{angle}}} F(\theta,\phi)d\omega \quad , \tag{26}$$

where $d\omega$ is the solid angle element and $F(\theta,\phi)$ is represented by either $i_1$, $i_2$ or $\frac{i_1 + i_2}{2}$, as indicated in Equations 18-20 for azimuthal symmetry.

A macroscopic scattering function, $Y(\theta,\lambda)$, may thus be obtained from the microscopic data for the differential scattering cross sections by the following integration:

$$Y(\theta,\lambda) = 2\pi/k^2 \int_{r_{min}}^{r_{max}} F(\theta,r/\lambda)n(r)dr \quad , \tag{27}$$

where $Y(\theta,\lambda)$ will be called the macroscopic phase function and has units $cm^{-1}$ $ster^{-1}$. The volume scattering cross section may then be calculated in a manner analogous to Equation 26:

$$A_{sc}(m,\lambda) = 2\pi \int_0^{180°} Y(\theta,\lambda)\sin\theta d\theta \quad . \tag{28}$$

The $Y(\theta,\lambda)$ may be normalized by

$$P(\theta,\lambda) = Y(\theta,\lambda)/A_{sc}(m,\lambda) \quad , \tag{29}$$

where $P(\theta,\lambda)$ is now the normalized phase function for photons of wavelength $\lambda$. $P(\theta,\lambda)$ represents the probability per steradian of a photon of wave length $\lambda$ being scattered in the direction $\theta$. In the computer program output this quantity is labeled the Differential Probability while $Y(\theta,\lambda)$ is labeled the Phase Function.

Another value which is useful in considering the forward momentum removed from the incident light beam (related to radiation pressure) is the average value of $\cos\theta$ , where $\theta$ is the scattering angle. This quantity may be determined from the expression

$$\overline{\cos\theta} = \frac{2\pi\int_{0°}^{180°} Y(\theta,\lambda)\cos\theta\sin\theta d\theta}{2\pi\int_{0°}^{180°} Y(\theta,\lambda)\sin\theta d\theta} \quad , \tag{30}$$

or

$$\overline{\cos\theta} = \frac{2\pi \int_{0^\circ}^{180^\circ} Y(\theta,\lambda)\cos\theta\sin\theta d\theta}{A_{sc}(m,\lambda)} \quad . \tag{31}$$

The forward momentum removed is then proportional to

$$A_{ext} - \overline{\cos\theta}\, A_{sc} \quad .$$

For use in the LITE codes (Ref. 1), a cumulative scattering probability is calculated which represents the probability of the photon being scattered through an angle $\theta$ that is equal to or less than some angle $\theta'$. This cumulative probability is defined at angles $\theta'$ corresponding to the scattering angles at which the phase function and differential probability are defined. This value, $CP(\theta',m,\lambda)$ is computed by the equation

$$CP(\theta',m,\lambda) = \frac{\int_{0^\circ}^{\theta'} Y(\theta,\lambda)\sin\theta d\theta}{\int_{0^\circ}^{180^\circ} Y(\theta,\lambda)\sin\theta d\theta} \quad . \tag{32}$$

From this function the cosines of the scattering angle $\theta'$ are calculated for values of $CP(\theta',m,\lambda)$ at equally spaced intervals from 0 to 1.

Three different functions are generally used to represent aerosol size distributions for varying atmospheric conditions. For continental hazes, the envelope of the observed $n(r)$ very often follows a power distribution of the form

$$n(r) = Ar^{-\nu} \tag{33}$$

where $\nu$ usually fall in the region from 2 to 4, depending upon the total particle concentration. For larger particle concentrations, $\nu$ tends toward the smaller values. The quantity A is an explicit function of the particle density whose value is dictated by relation 22. The macroscopic values

calculated using this size distribution is dependent upon the lower and upper limits of r used in the integration. However, in many cases, the size distribution has a constant value at lower radii, while virtually no particles appear below a certain radius. In order to closely represent this distribution, Equation 33 may be altered to the form

$$\begin{aligned} n(r) &= 0 & & r<r_{min} \\ n(r) &= \text{constant} & & r_{min}\le r\le r_2 \\ n(r) &= Ar^{-\nu} & & r_2\le r\le r_{max} \quad , \end{aligned} \qquad (34)$$

where $r_2$ is some intermediate radius. The particular distribution obtained when $\nu = 4$, $r_2 = .1\mu$, and $r_{mir} = .03\mu$, has been suggested by Deirmendjian (Ref. 4) to be representative of typical continental hazes of fairly low turbidity. Deirmendjian has denoted this distribution model as "Haze C."

For hazes formed primarily by water spheres or by condensation nuclei covered by a relatively thick water blanket, a size distribution of the form

$$N(r) = Ar^{\alpha}\exp(-Br^{\beta}) \qquad (35)$$

is often used as a representation of the particle size distributions. Deirmendjian (Ref. 4) has performed calculations for two distributions of the type shown in Equation 35. The first, denoted "Haze M," was chosen by Deirmendjian to represent a typical coastal haze with mode radius $r_{mode}$ = .05μ. The Haze M distributions is expressed by

$$n(r) = A\ r\ \exp(-8.944r^{\frac{1}{2}}) \qquad (36)$$

where A is dependent upon the number density. Another distribution of the same form was chosen by Deirmendjian to describe a typical cumulus cloud

particle size distribution with mode radius $r_{mode} = 4\mu$, and is given by

$$n(r) = A\, r^6 \exp(-1.5r) \quad . \tag{37}$$

A machine program, RRA-45, has been written for use in calculating the quantities defined by Equations 24, 25, 27, 28, 29, 31 and 32. This program may be used in integrating the microscopic values over size distributions of forms expressed by Equations 33, 34, 35 and of forms defined by tabular data. Some of the computational results for various aerosol models are discussed in Section III. Utilization instructions, a sample problem, and the program listing are given in Section V.

## III. SELECTED RESULTS

Several test problems were run on RRA-42 and RRA-45 before full-scale data production was undertaken, using size parameters and indices of refraction corresponding to those used by other investigators, thus allowing a comparison of their results with the RRA-42 and RRA-45 calculations.

### 3.1 Microscopic Data

Using a refractive index of 1.315 - 0.0143i, RRA-42 calculations were performed for size parameters ranging from 0.25 to 15.0. The scattering amplitudes, $S_1$, for this refractive index and size parameter range have been tabulated by Deirmendjian (Ref. 3) for scattering angles of 0° and 180°. Results calculated by RRA-42 are in exact agreement with these values for the four significant figures tabulated by Deirmendjian. Values of $S_1$ and $S_2$ at other angles and the extinction and scattering efficiencies as computed by RRA-42 agree with graphical data presented in Deirmendjian's report.

Penndorf (Ref. 5) has published tables of Mie coefficients for various real refractive indices. A comparison of Penndorf's data with calculations by RRA-42 shows agreement to five or six significant figures in nearly all cases. For large size parameters, some discrepancies were noted when comparing Penndorf's calculations of $a_n$ and $b_n$ for very large values of n with similar results from RRA-42. Small discrepancies may also be noted in some of the following comparisons for small size parameters. These differences are believed to be due to the different methods used in terminating the Mie series or to machine roundoff error.

All of the infinite series used for the calculation of the amplitude functions and efficiencies in RRA-42 were terminated either when

$$\frac{|a_n|^2 + |b_n|^2}{n} < 10^{-14} ,$$

or when

$$n = 1.2\ x + 9 ,$$

as suggested by Deirmendjian in Reference 3. For small values of the size parameter x, a variation in the criterion for terminating the series may result in a difference in the values for the amplitude functions and efficiencies, since a difference in $n_{max}$ of 1 or 2 between two series of only four or five terms may be significant. Also, when using recurrence formulae for the calculation of $a_n$ and $b_n$, as well as for $\pi_n$ and $\tau_n$, their convergence properties depend upon the accuracy of all the preceding terms of the series Thus, small "round off" errors made by the computer in the initial terms will cause larger errors in the terms with large n. These variations may be noted even when one particular problem is run on two different types of computers, or when the series of arithmetic statements used in the calculations varies slightly. However, investigation has shown that recognizable variation in the values of $a_n$ and $b_n$ occur only at those terms which contribute so little to the summation that the discrepancy is virtually insignificant. Therefore, the sacrifice of computational speed by the use of double or extended precision arithmetic by the codes does not seem to be justified for most purposes. This is especially true since the error introduced by numerical integration techniques when integrating the Mie data over an arbitrary aerosol size distribution is much larger than these small variations.

The extinction efficiency $Q_{ext}$ for a size parameter of 30 and a real index of refraction of 1.44 from three different calculations is shown below.

$Q_{ext}$, Extinction Efficiency

| RRA-42 | Penndorf (Ref. 5) | Gumprecht-Sliepcevich (Ref. 6) |
|---|---|---|
| 2.042650 | 2.0426 | 2.043 |

Calculations for size parameters ranging from 0.10 to 40 and for a refractive index of 1.59 - 0.66i have been performed for comparison with similar results performed with an NBS code (Ref. 7). A comparison of the extinction and scattering efficiencies for several size parameters in this size range is shown in Table I.

Table I. Comparison of RRA-42 and NBS Code Results

| X | Efficiency | RRA-42 | NBS Code |
|---|---|---|---|
| 0.1 | Extinction | 1.200272-01* | 1.20025373167-01 |
| | Scattering | 7.073438-05 | 7.07385352988-05 |
| 1.0 | Extinction | 1.793323+00 | 1.7933235+00 |
| | Scattering | 4.643367-01 | 4.6433718-01 |
| 5.0 | Extinction | 2.556082+00 | 2.5560821+00 |
| | Scattering | 1.235118+00 | 1.2351177+00 |
| 10.0 | Extinction | 2.381907+00 | 2.3819072+00 |
| | Scattering | 1.249081+00 | 1.2490814+00 |
| 20.0 | Extinction | 2.254031+00 | 2.2540314+00 |
| | Scattering | 1.245271+00 | 1.2452710+00 |
| 40.0 | Extinction | 2.165485+00 | 2.1654845+00 |
| | Scattering | 1.232702+00 | 1.2327021+00 |

* Read 1.200272-01 as 1.200272 x $10^{-1}$

Values obtained for other quantities ($S_1$, $S_2$, $i_1$, $i_2$) show agreement to either four or five significant digits.

In preparation for the analysis of light scattering by realistic aerosol distributions, extensive data were produced for two real indices of refraction, 1.33 and 1.50. The index of 1.33, for liquid water at visible wave lengths, was chosen for calculations involving clouds, fogs and water hazes. The index of 1.50 is believed to represent an average index for continental hazes. RRA-42 calculations were performed for size parameters ranging from .001 to 320. These data were stored on magnetic tapes for use as library tapes for RRA-45. Figures 1 through 3 show the extinction (and scattering, since there is no absorption with a real refractive index) efficiency plotted as a function of the size parameter for indices of refraction of 1.33 and 1.5. Penndorf's calculations for size parameters less than 1.0 are compared in Figure 1 with the RRA-42 data. The smooth curves in Figure 1 were drawn through the RRA-42 data. For the larger size parameters, the RRA-42 values have been joined by straight lines. It can be seen that it is possible that some of the oscillations have not been well defined, but an investigation of the sensitivity during integration of the extinction efficiency to the coarseness of the size parameter increment for larger values of x shows little variation with changing x increment, within certain limits. However, the effects of "holes" in the upper size parameter range upon the phase function for certain size distributions was not sufficiently studied before the generation of the microscopic library tapes. The effect of this lack of definition upon a cloud function will be noted later. Figures 2

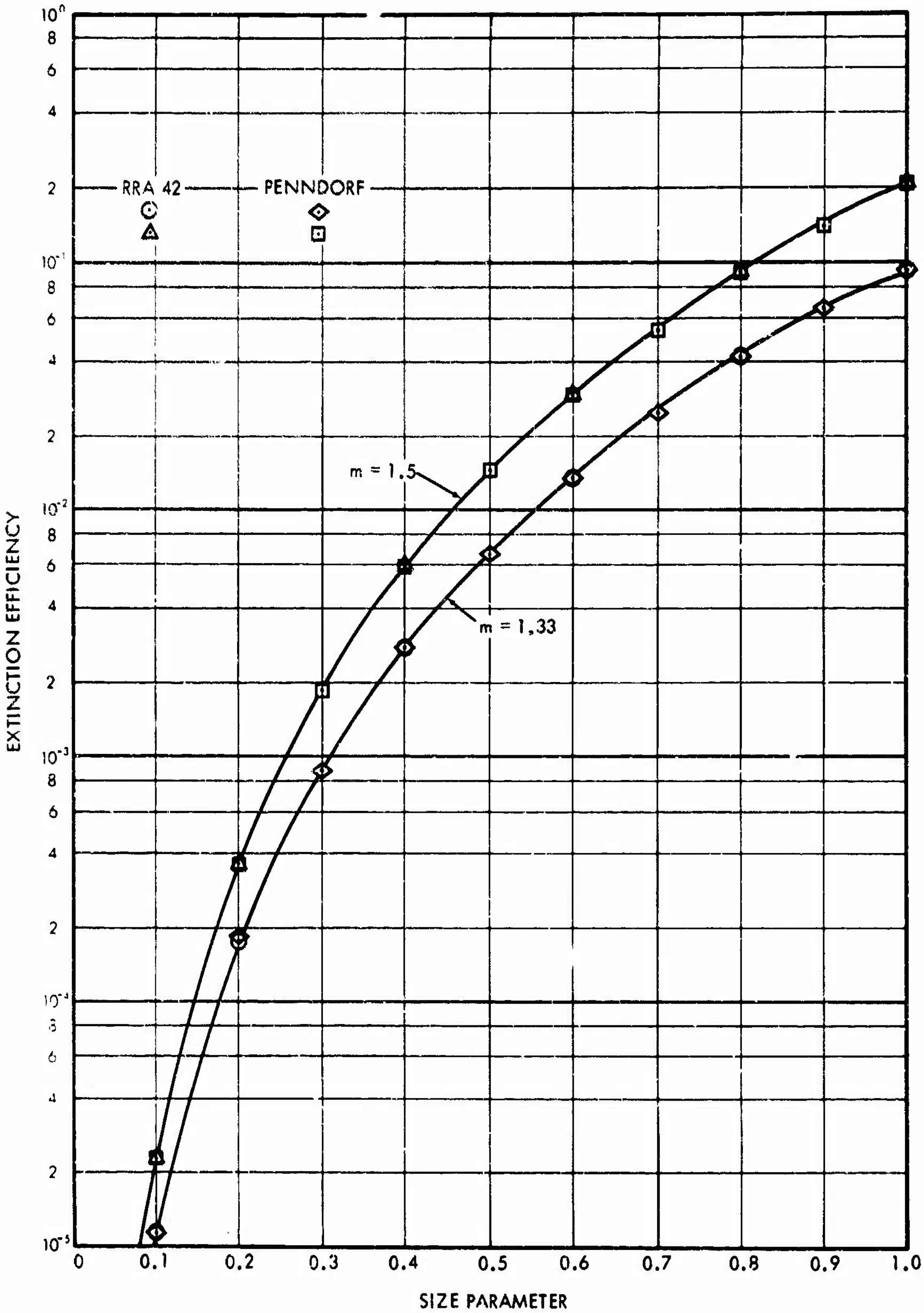


Fig. 1. Extinction Efficiency for Size Parameters Between 0.1 and 1.0: m = 1.33 and 1.5

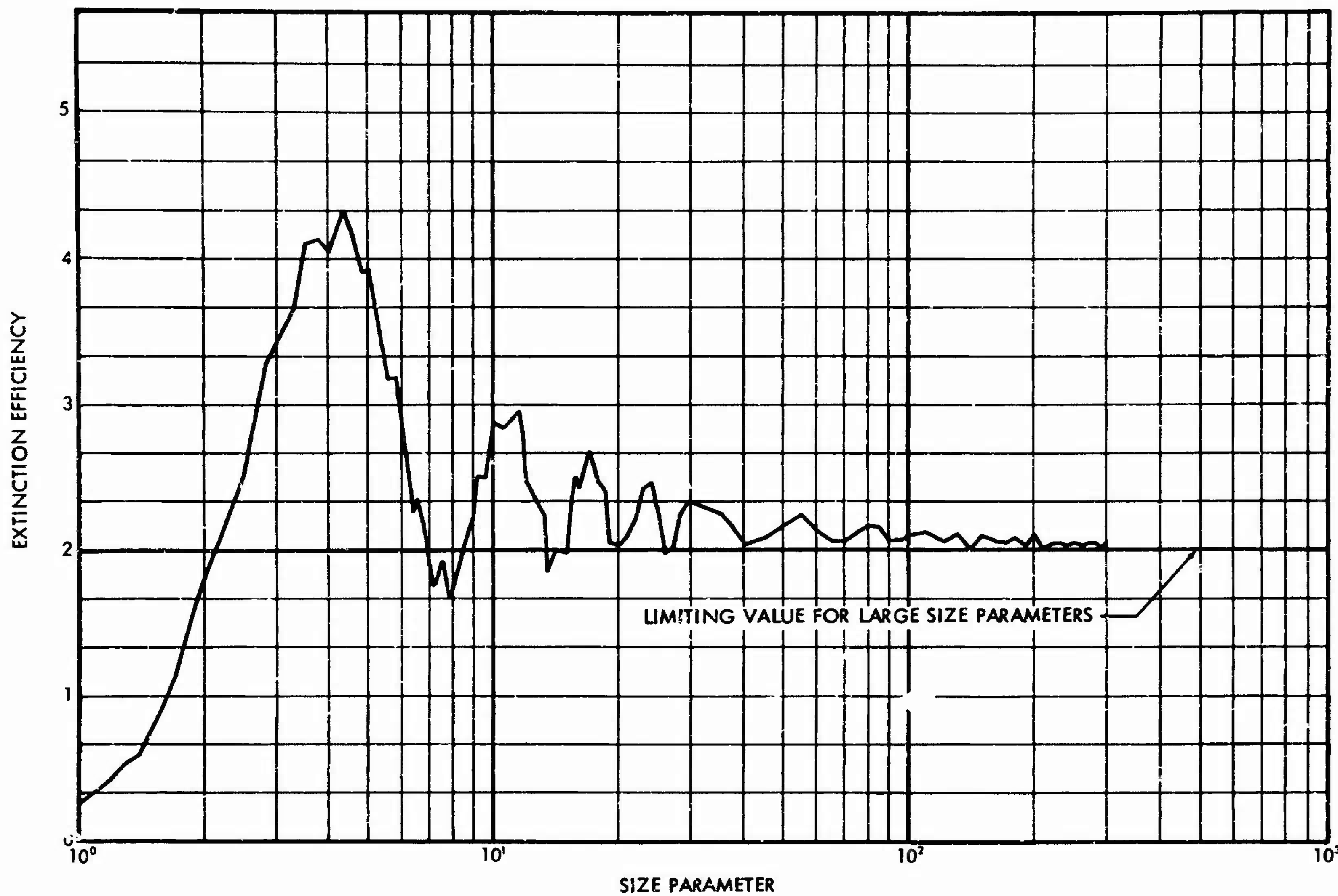


Fig. 2. Extinction Efficiency for Size Parameters Greater than 1.0: m = 1.50

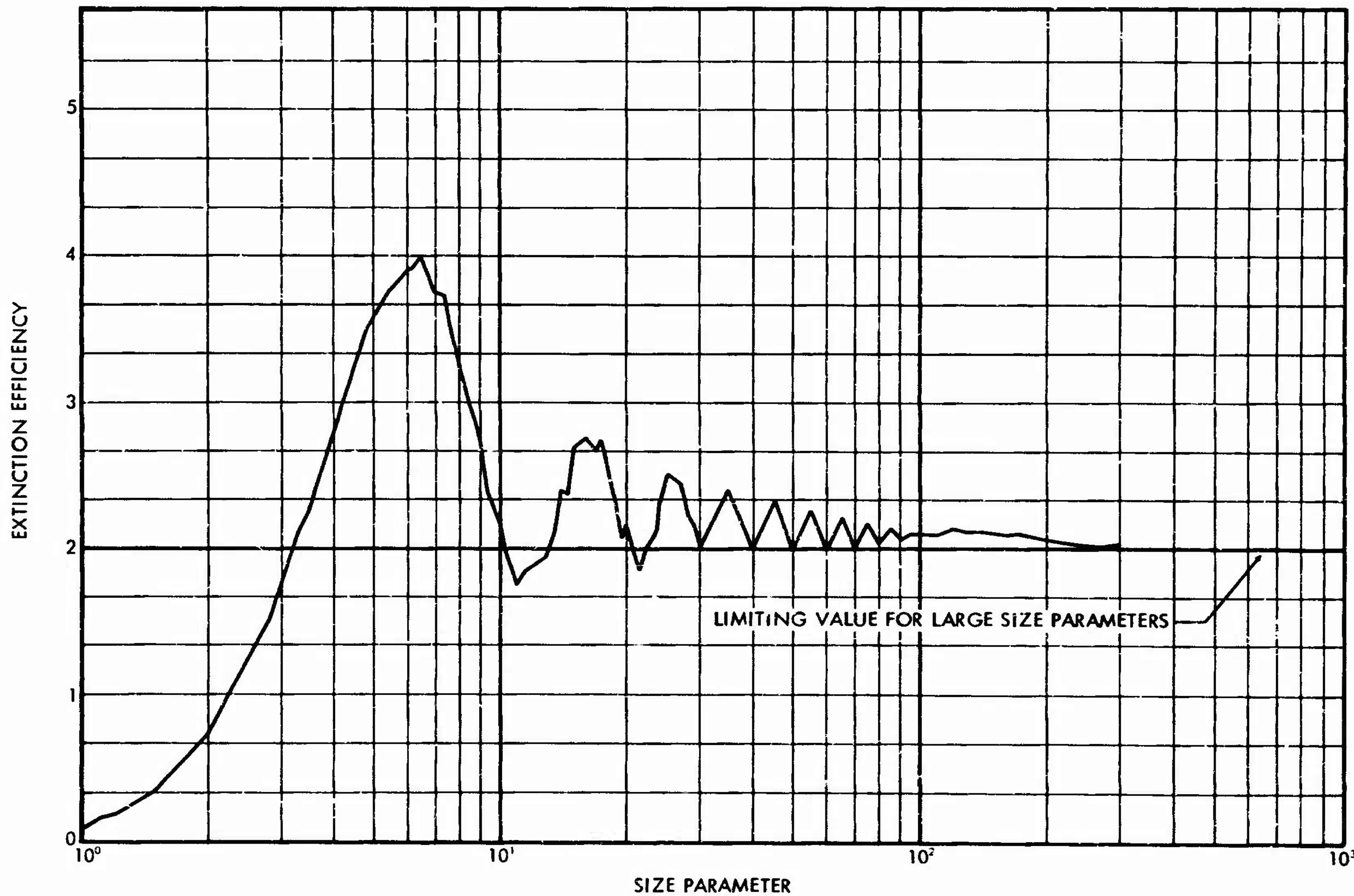


Fig. 3. Extinction Efficiency for Size Parameters Greater than 1.0: m = 1.33

and 3 also show that in accordance with classical theory, the extinction efficiency converges to 2 as x becomes large.

The effects of an imaginary part in the refractive index upon the efficiency functions can be seen by a comparison of Figures 2 through 5, where Figures 4 and 5 are plots of the limited data calculated for indices 1.315 - 0.143i and 1.59 - 0.66i. The extinction efficiency curve is smoothed somewhat by the addition of a small amount of absorption with the 1.315 - .0143i index. This smoothing effect is very pronounced with the addition of strong absorption with the 1.59 - 0.66i index. This indicates that the size parameter increment for x>10 may be increased as the absorption increases without loss of accuracy for integration purposes.

In calculating the microscopic phase functions, $i_1$ and $i_2$, the question arises as to the increment in scattering angle from 0° to 180° necessary to adequately describe these functions. For particles with real index of refraction, the phase functions show oscillations appearing with angular frequencies 180°/x. Assuming a minimum of three or four points necessary to adequately describe each oscillation, the exact representation of phase functions from scattering by particles with sizes extending up to x=300 becomes extremely unattractive. However, experimental measurements of phase functions for various aerosol distributions exhibit no numerous radical oscillations. Also, calculations show that when the phase functions for given particle sizes are integrated over any size distribution of extended width, the extreme oscillations noted in the microscopic data are smoothed to varying degrees. The integration of the phase function data shows less sensitivity to the angular increment than to the size parameter increment.

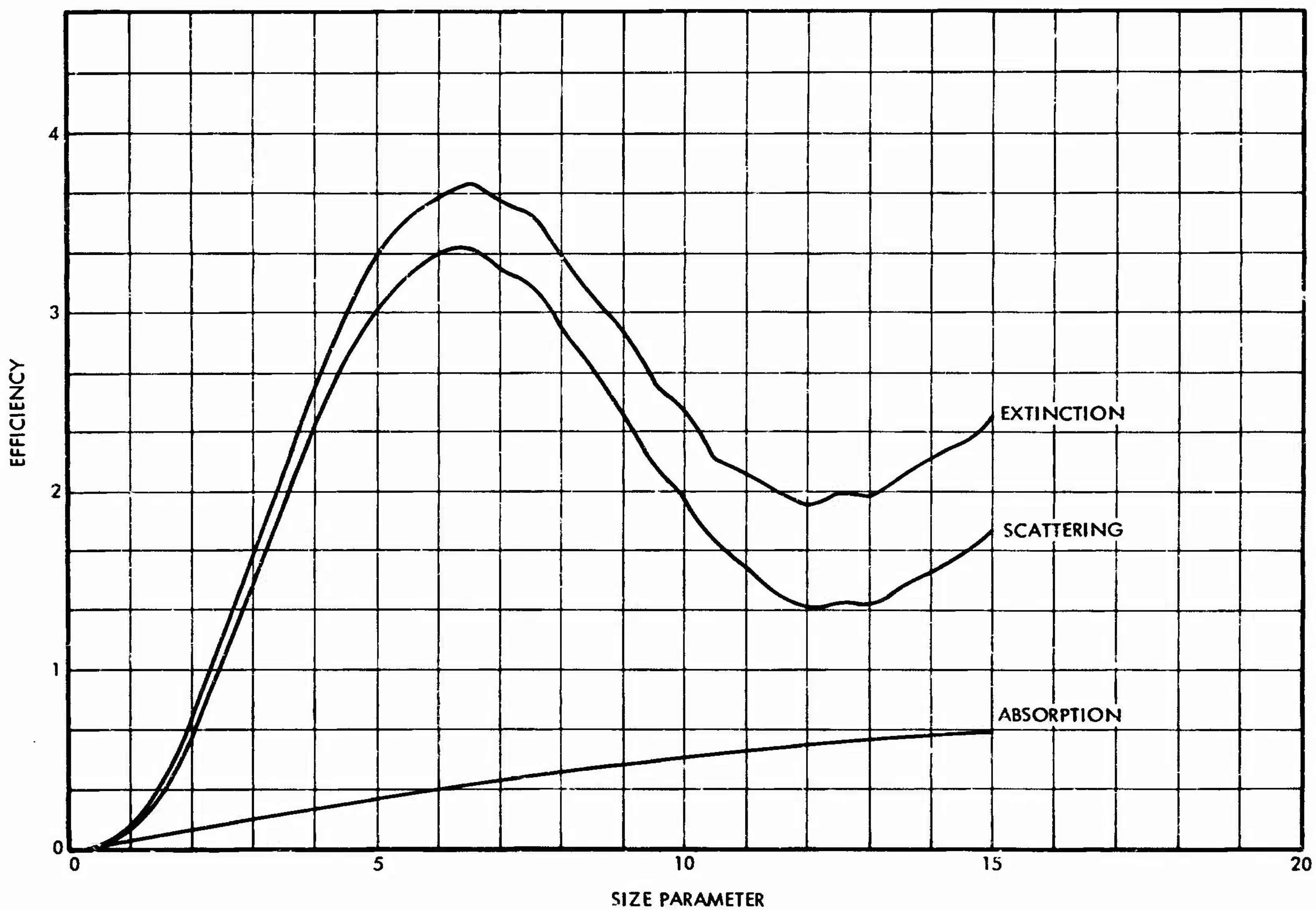


Fig. 4. Extinction, Scattering, and Absorption Efficiencies vs Size Parameter: m = 1.315 - 0.0143 i

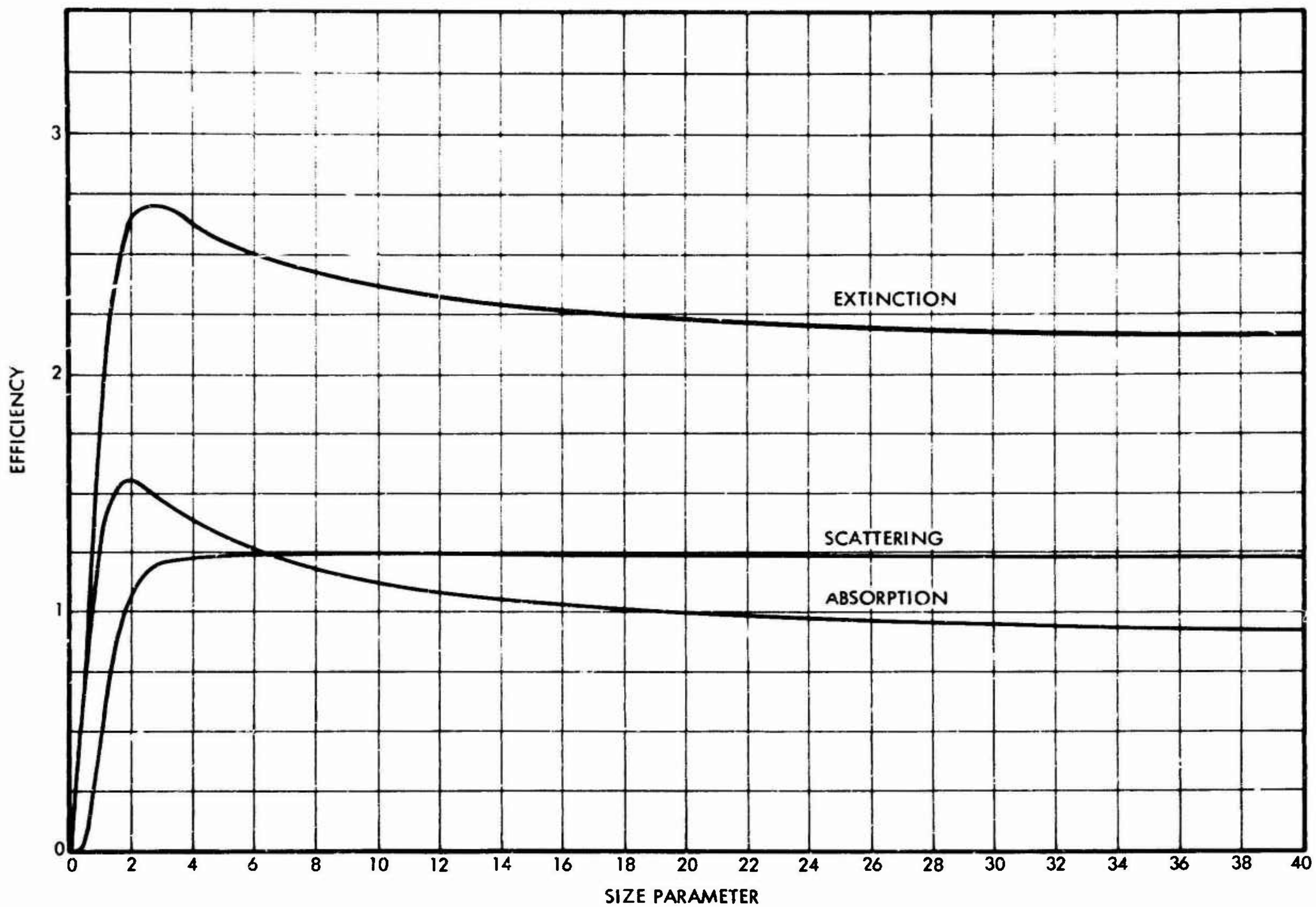


Fig. 5. Extinction, Scattering, and Absorption Efficiencies vs Size Parameter: $m = 1.59 - 0.66\,i$

On the basis of the angular increment found necessary to properly describe the integrated phase functions, the microscopic data were computed with three values of $\Delta\theta$ or where $\theta = 0°(1°)20°(2.5°)155°(1°)180°$. The forward-scattering and back-scattering peaks were deemed the more sensitive to changes in the particle size distribution, hence the smaller $\Delta\theta$ in these regions. Also, much sharper peaks in the phase functions are found in these areas than in the intermediate angular range.

Figures 6 through 13 show the phase functions $\frac{i_1 + i_2}{2}$, $i_1$ and $i_2$ for a few values of x, illustrating the effects of increasing the particle size. The latter figures show the smoothing effect of the imaginary part of the refractive index upon the phase function and polarization. It can be seen from Figures 6 and 7 that the phase function, $\frac{i_1 + i_2}{2}$, approaches the shape of the phase function for Rayleigh scattering as the size parameter decreases. For $x = 0.001$ the phase function corresponds closely to that predicted by Rayleigh scattering.

3.2 Macroscopic Data

RRA-45 calculations have been performed using the three distributions described by Equations 34, 36 and 37 in addition to distributions of the type shown in Equation 33 for $\gamma$ = 2, 2.5, 3, 3.5, and 4. Calculations with the Haze C, Haze M and cloud distributions were done for real refractive indices of 1.33 and 1.50 and for wave lengths of 0.30, 0.45, 0.50, 0.65, and 0.70 microns in an attempt to describe the scattering for the visible portion of the spectrum. The power law distributions of the form expressed by Equation 41 were used in calculations for an index of refraction of 1.50 and for the wave lengths listed above. All size

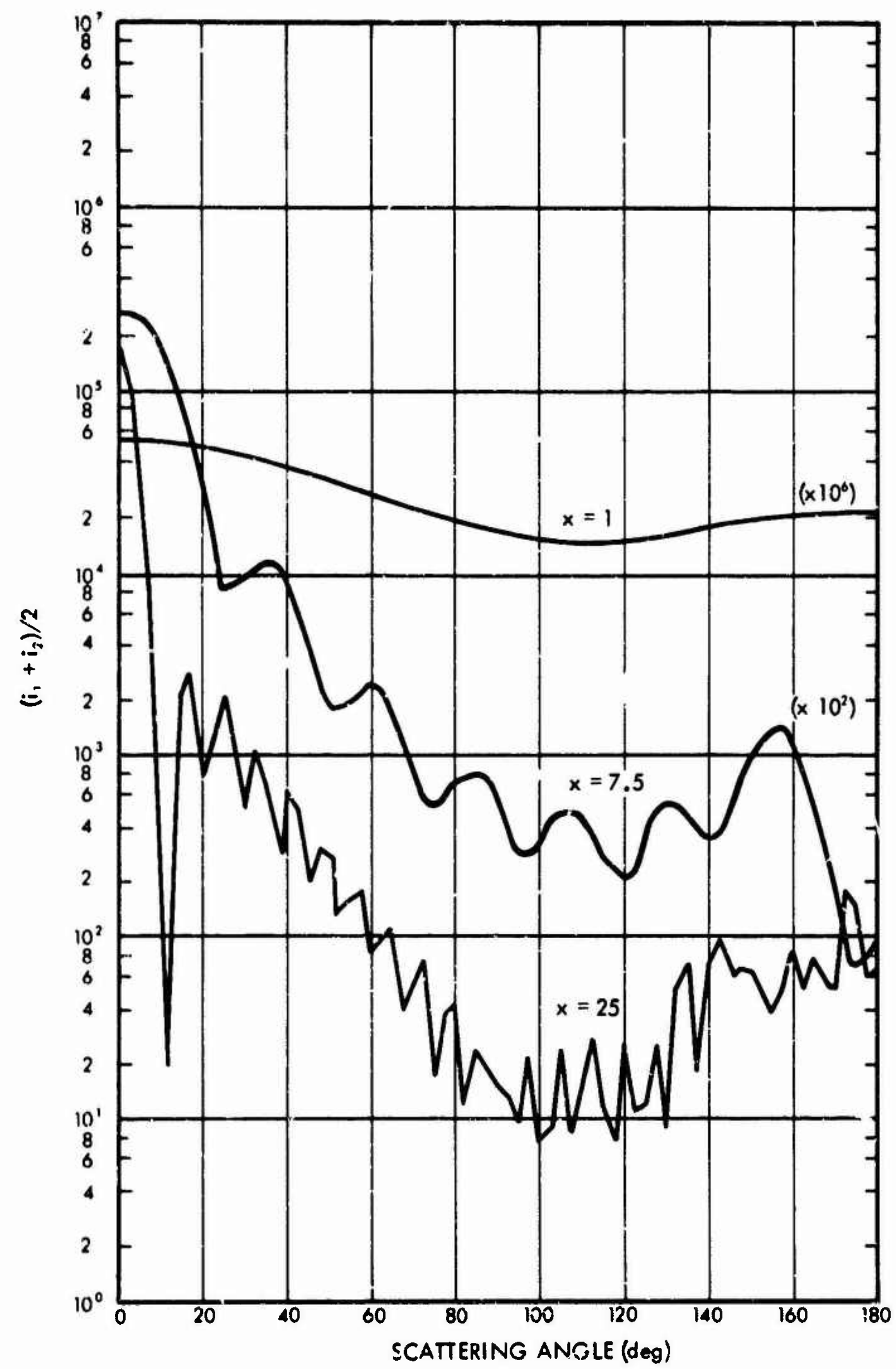


Fig. 6. Phase Function vs Scattering Angle for Size Parameter of x = 1.0, 7.5, and 25.0; m = 1.33

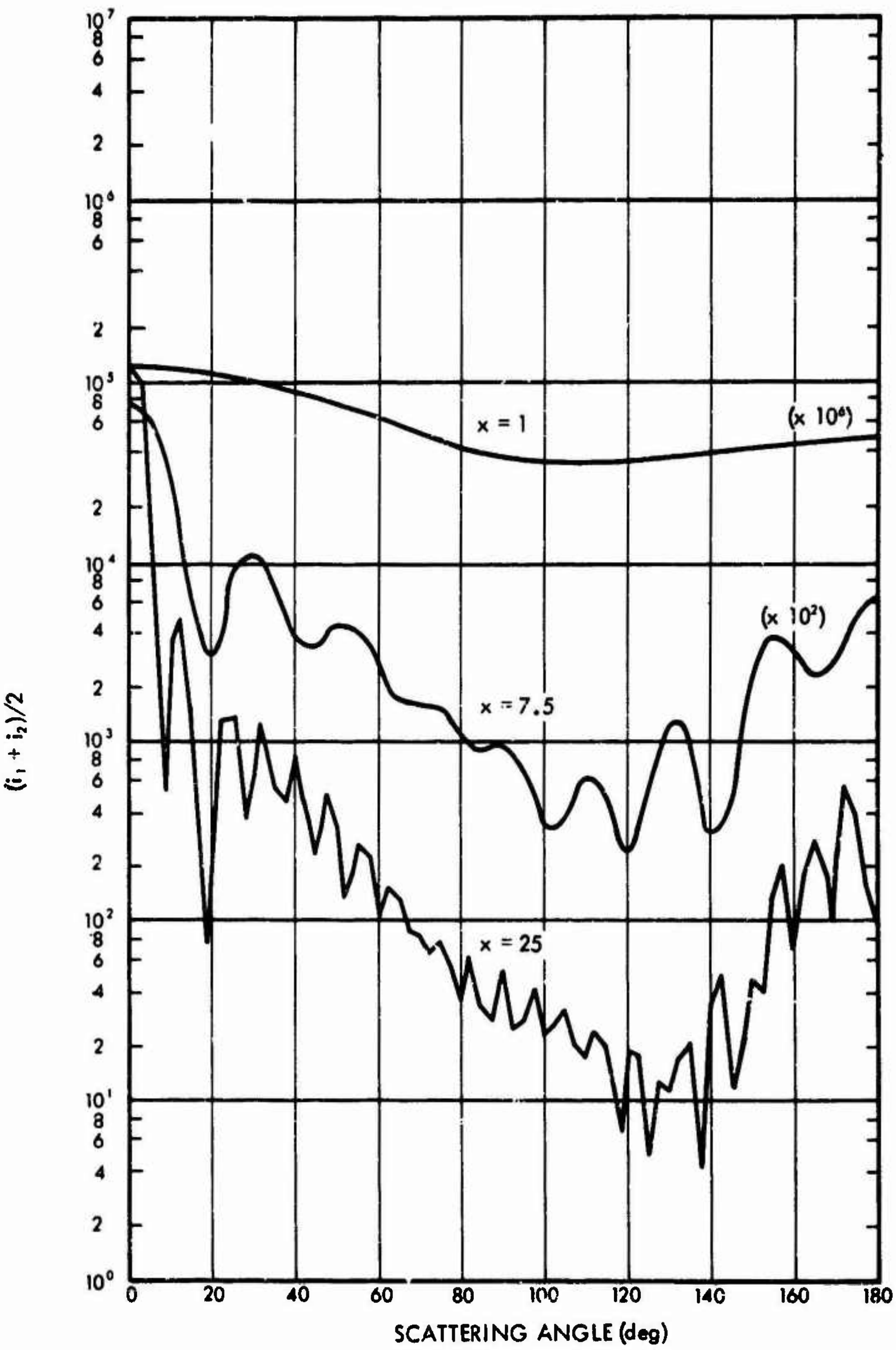


Fig. 7. Phase Function vs Scattering Angle for Size Parameters of x = 1.0, 7.5, and 25.0: m = 1.50

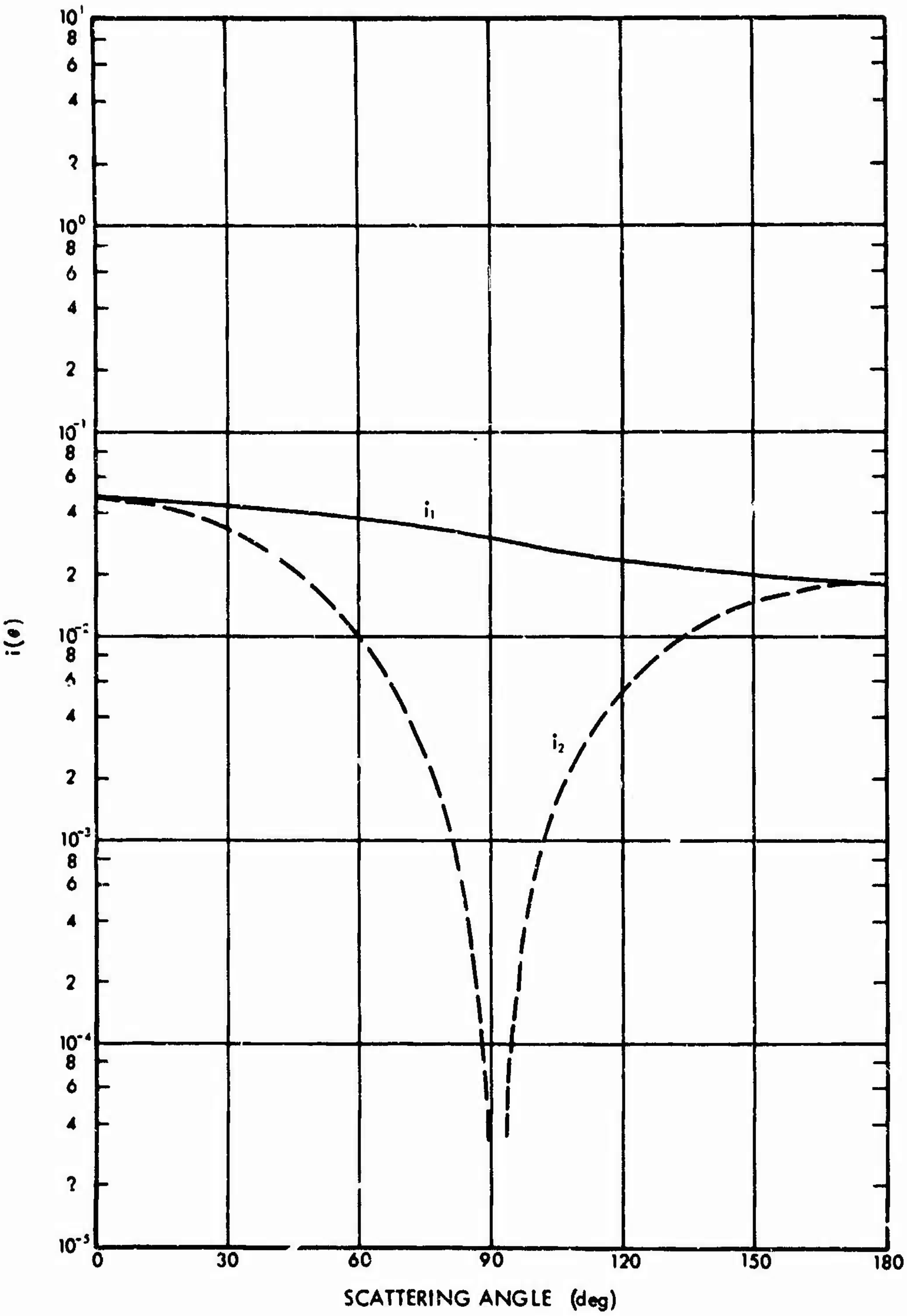


Fig. 8. Variation of $i_1$ and $i_2$ with Scattering Angle for $x = 1.0$: $m = 1.315-0.0143i$

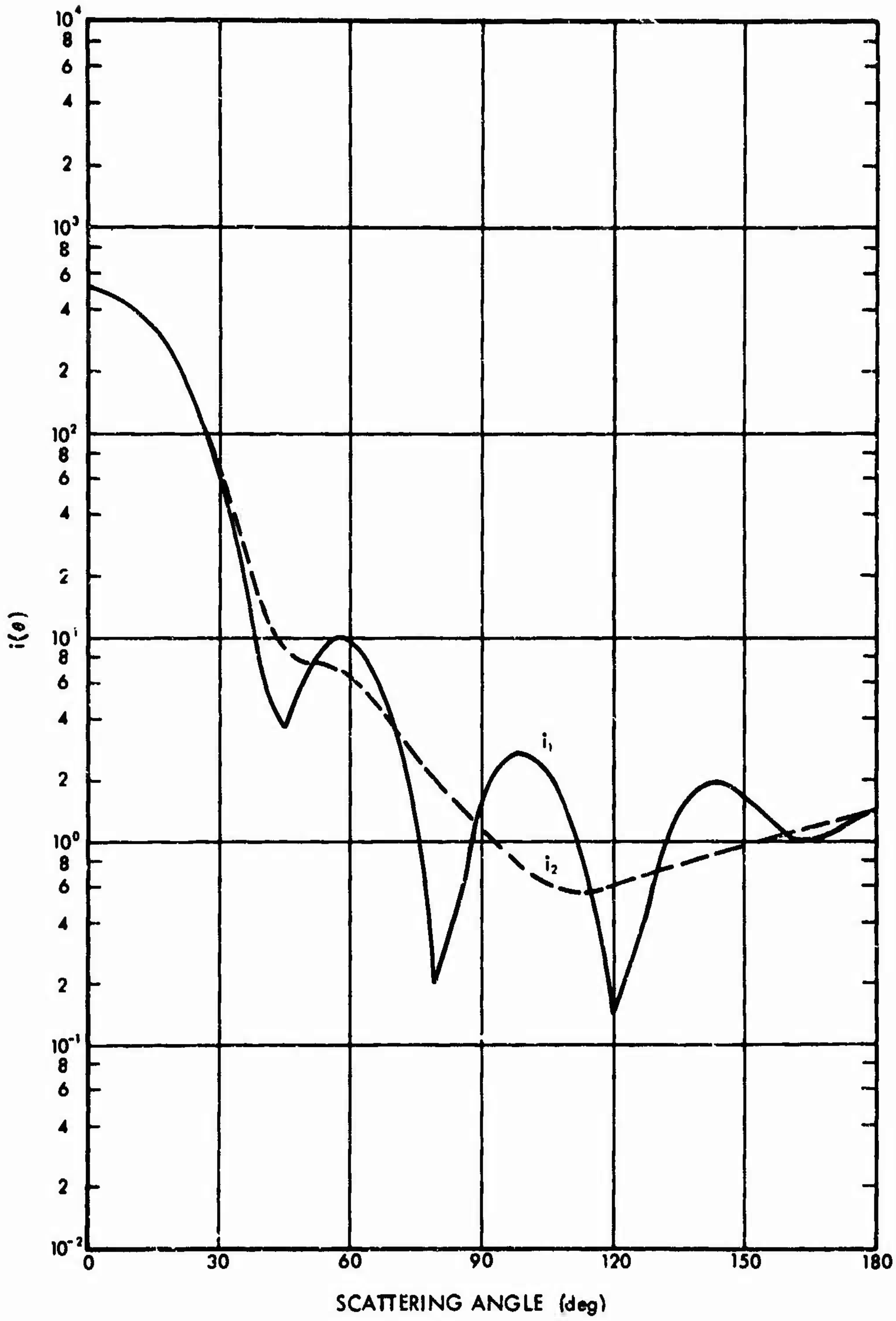


Fig. 9. Variation of $i_1$ and $i_2$ with Scattering Angle for $x = 5.0$: $m = 1.315-0.0143i$

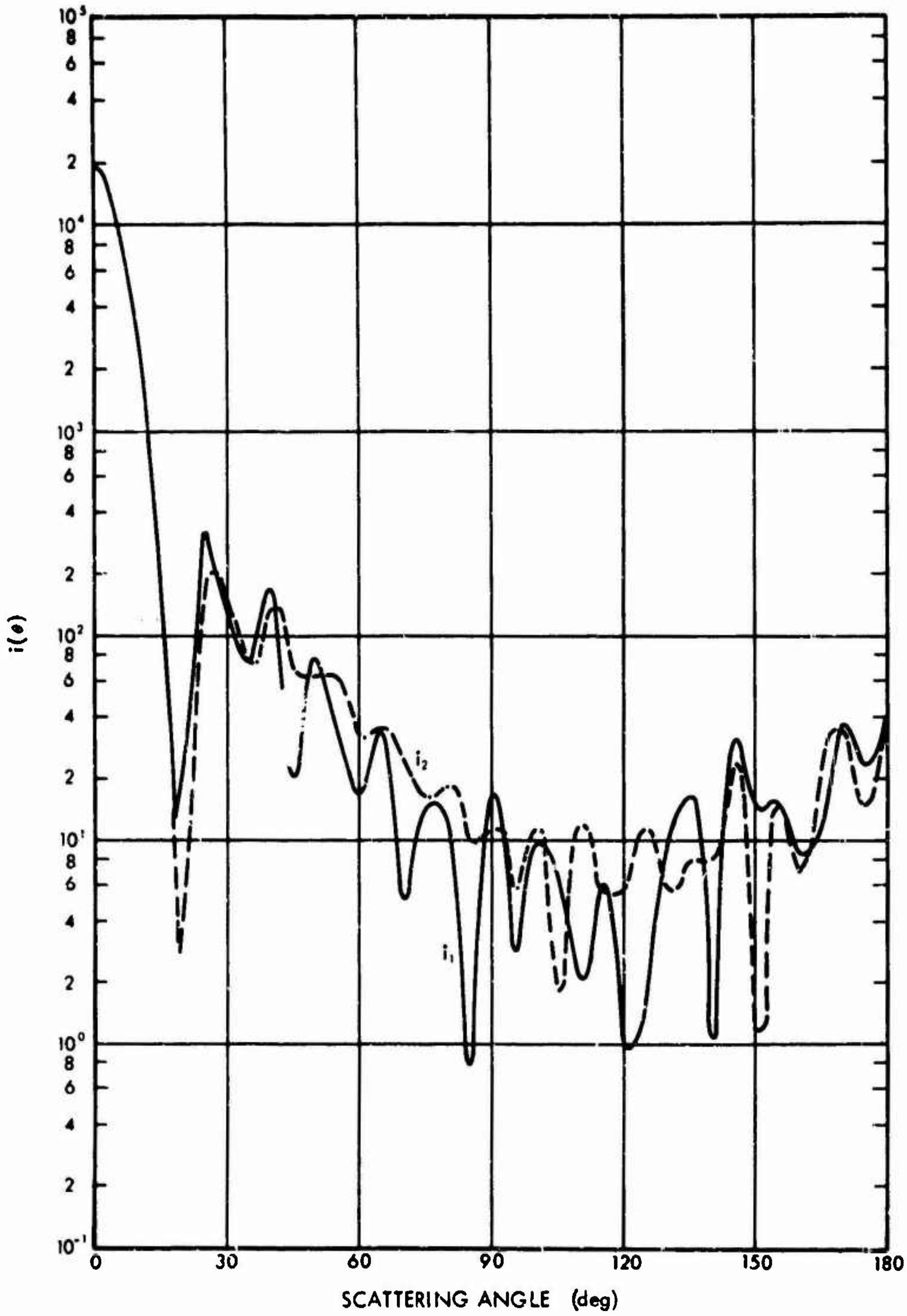


Fig. 10. Variation of $i_1$ and $i_2$ with Scattering Angle for $x = 15.0$: $m = 1.315-0.0143i$

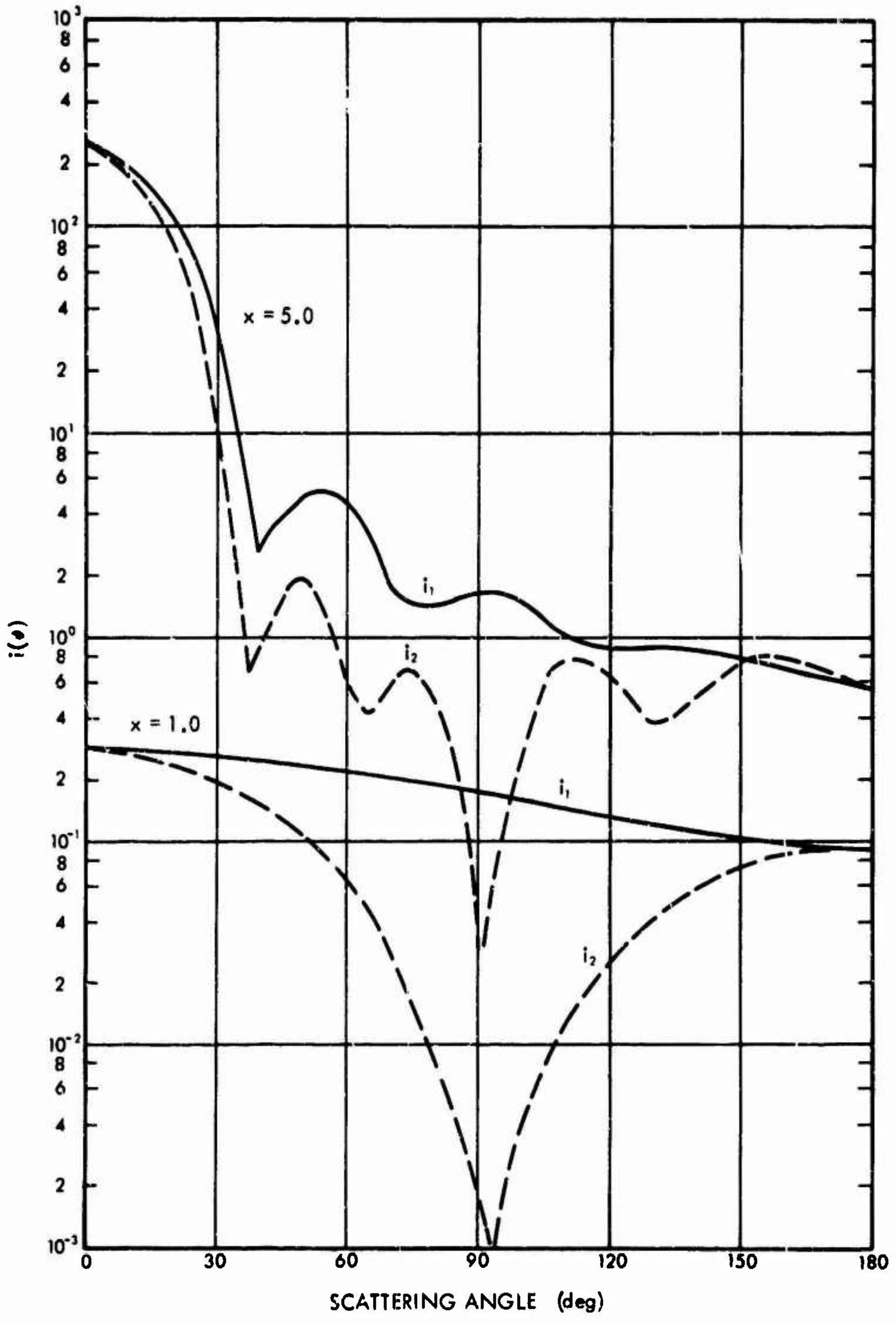


Fig. 11. Variation of $i_1$ and $i_2$ with Scattering Angle for x = 1.0 and x = 5.0: $n$ = 1.59–0.66i

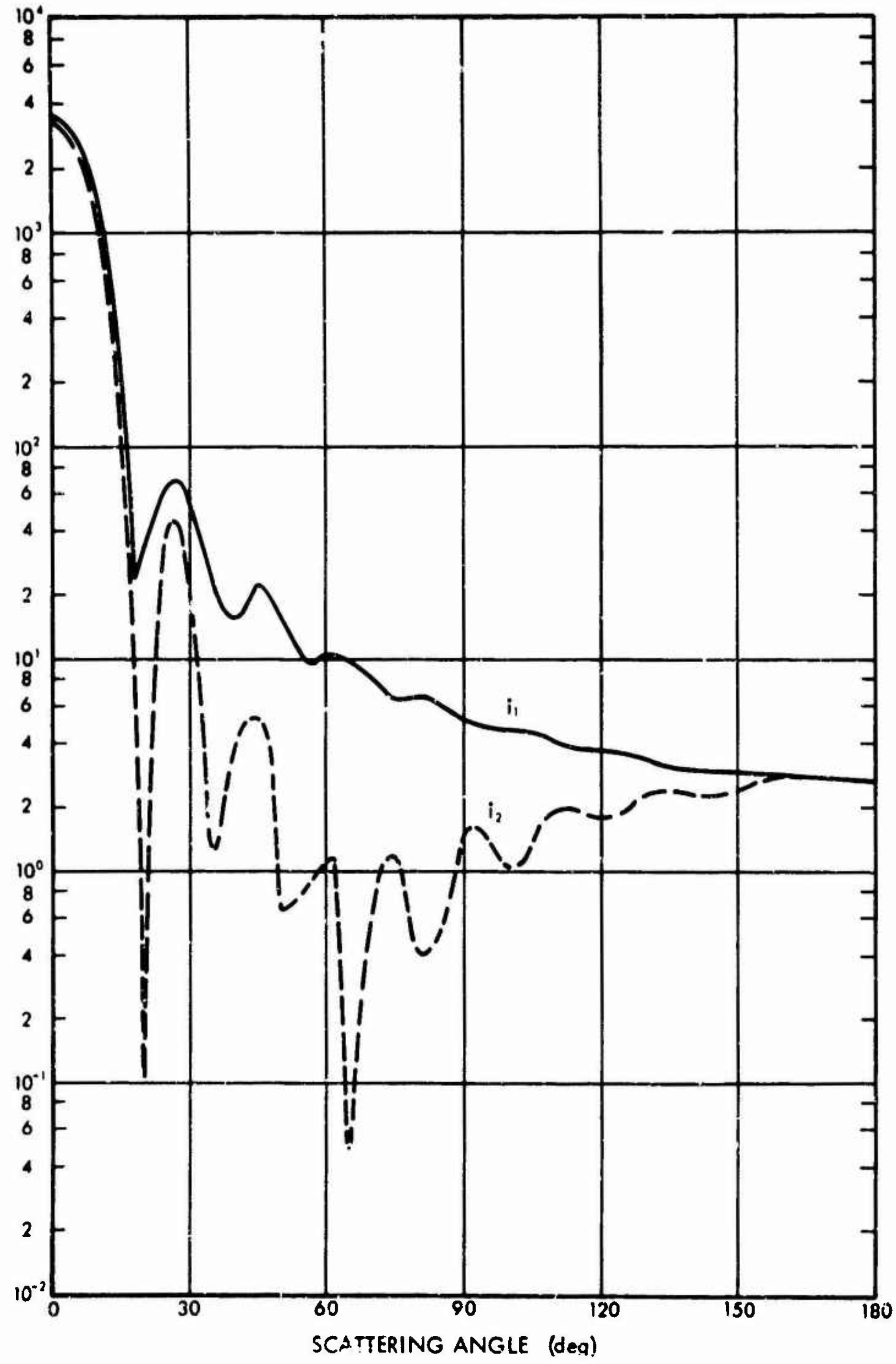


Fig. 12. Variation of $i_1$ and $i_2$ with Scattering Angle for $x = 10.0$; $m = 1.39-0.66i$

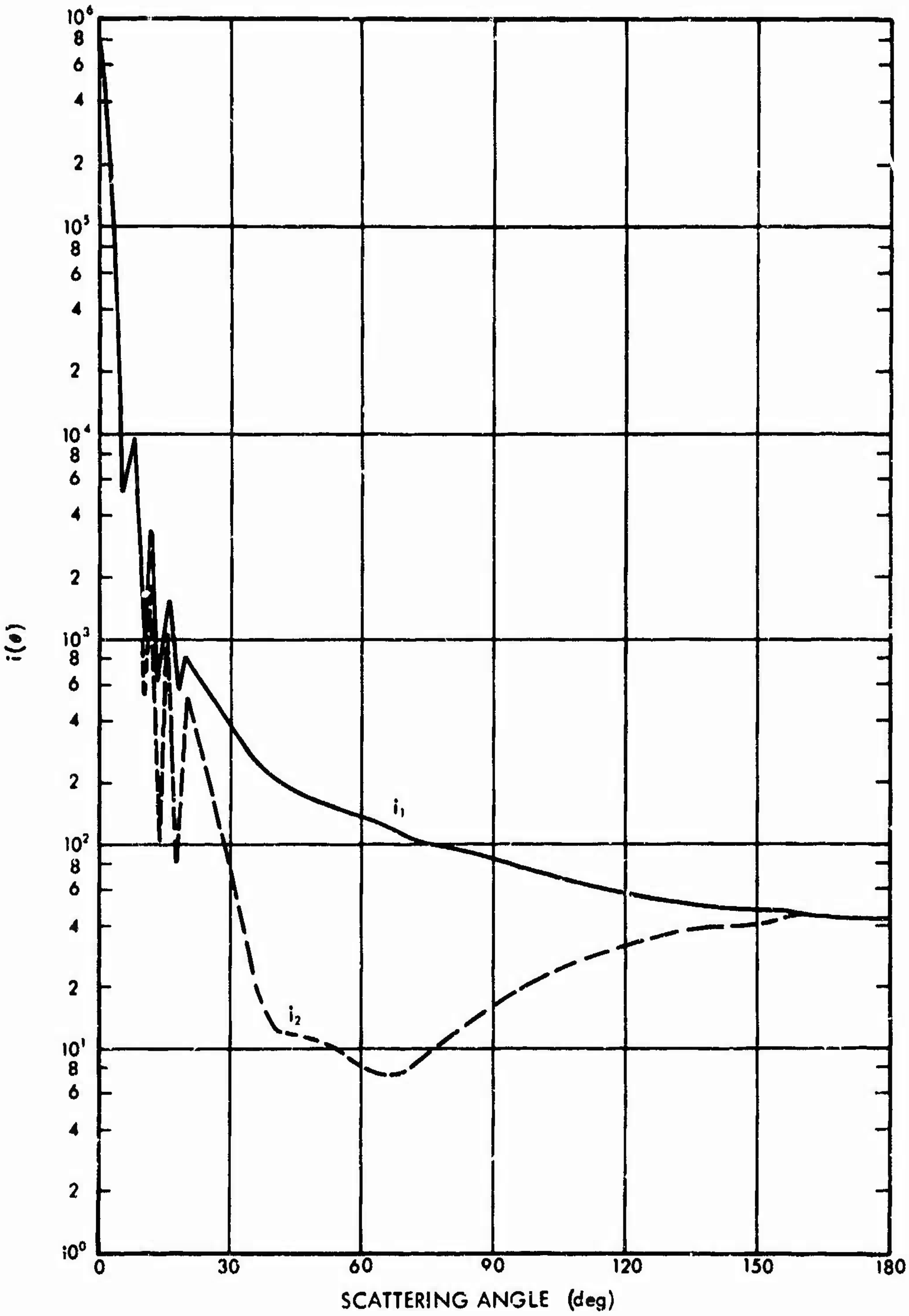


Fig. 13. Variation of $i_1$ and $i_2$ with Scattering Angle for $x = 40.0$; $m = 1.59-0.66i$

distributions considered in this study were integrated over the size range $r = 0.03\mu$ to $10\mu$. Plots of the size distribution for Haze C, Haze M, and the cloud model are shown in Figure 14.

Several preliminary test problems were run for comparison with similar results obtained by other investigators. One such problem duplicates a calculation performed by Deirmendjian (Ref. 4) using the cloud distribution. The size distribution given by $n(r) = 2.373r^6 \exp(-1.5r)$ for a number density of 100 particles/$cm^3$ was used with the microscopic cross section data for a complex index of refraction of $m = 1.315 - 0.0143i$ to compute the volume scattering, absorption and extinction coefficients and the volume scattering function for light with a wave length of 5.30 microns. Figure 16 shows the calculated normalized phase function while Figure 17 shows the cumulative scattering probability as defined in Equation 31. The printed output for this problem is given as sample problem output in Section IV.

The curve in Figure 16 is in good agreement with the average value of the graphical data for $i_1/\Sigma_{sc}$ and $i_2/\Sigma_{sc}$ as given by Deirmendjian in Reference 4 for the same size distribution and index of refraction. A comparison of the extinction cross section and the albedo, which is defined as the ratio $\Sigma_{sc}/\Sigma_{ext}$, is shown below.

| | RRA-45 | Deirmendjian |
|---|---|---|
| $\Sigma_{ext}$ | 2.410-04($cm^{-1}$) | 2.401-04($cm^{-1}$) |
| Albedo | 0.883 | 0.884 |

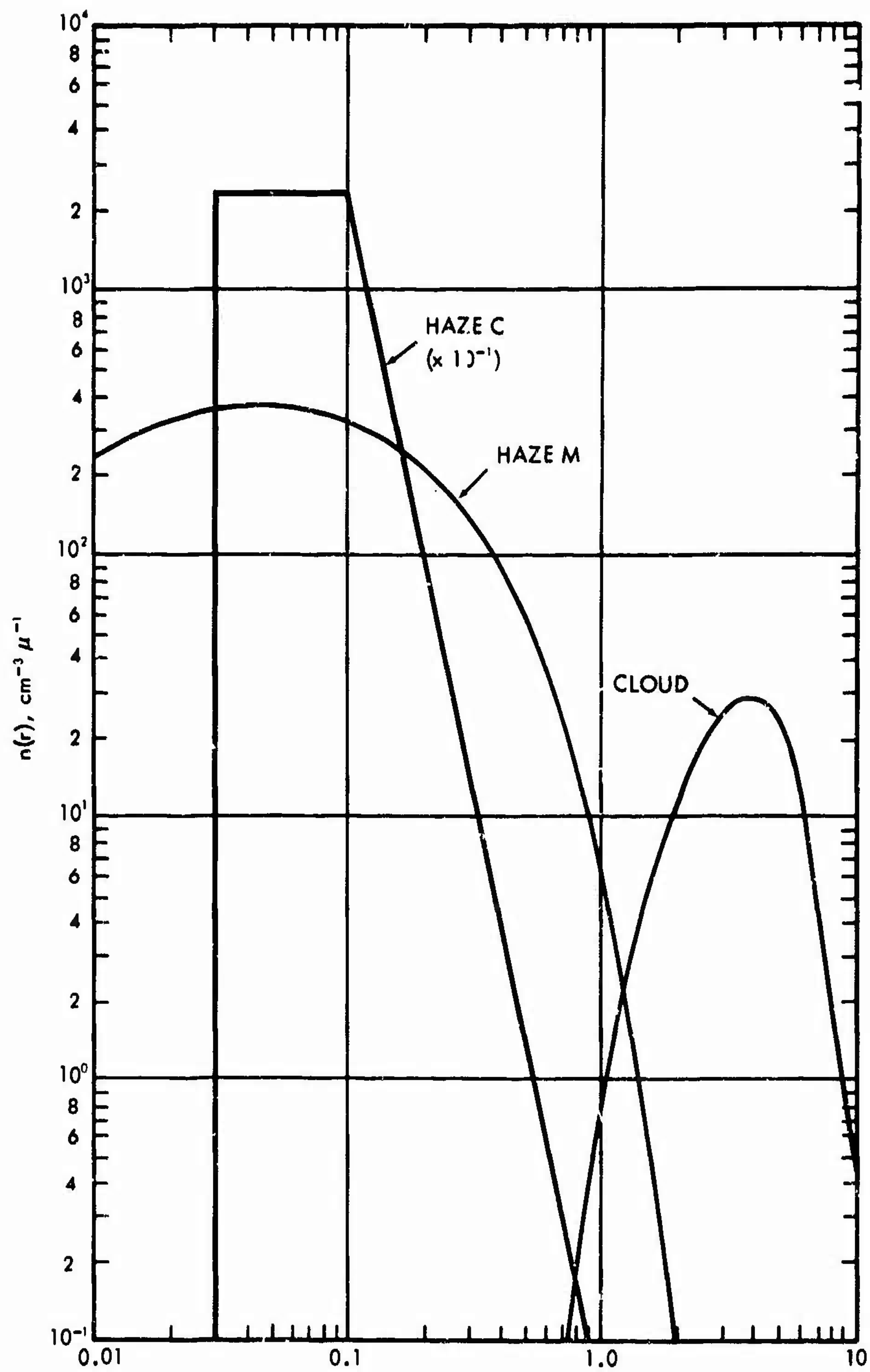


Fig. 14. Aerosol Size Distributions

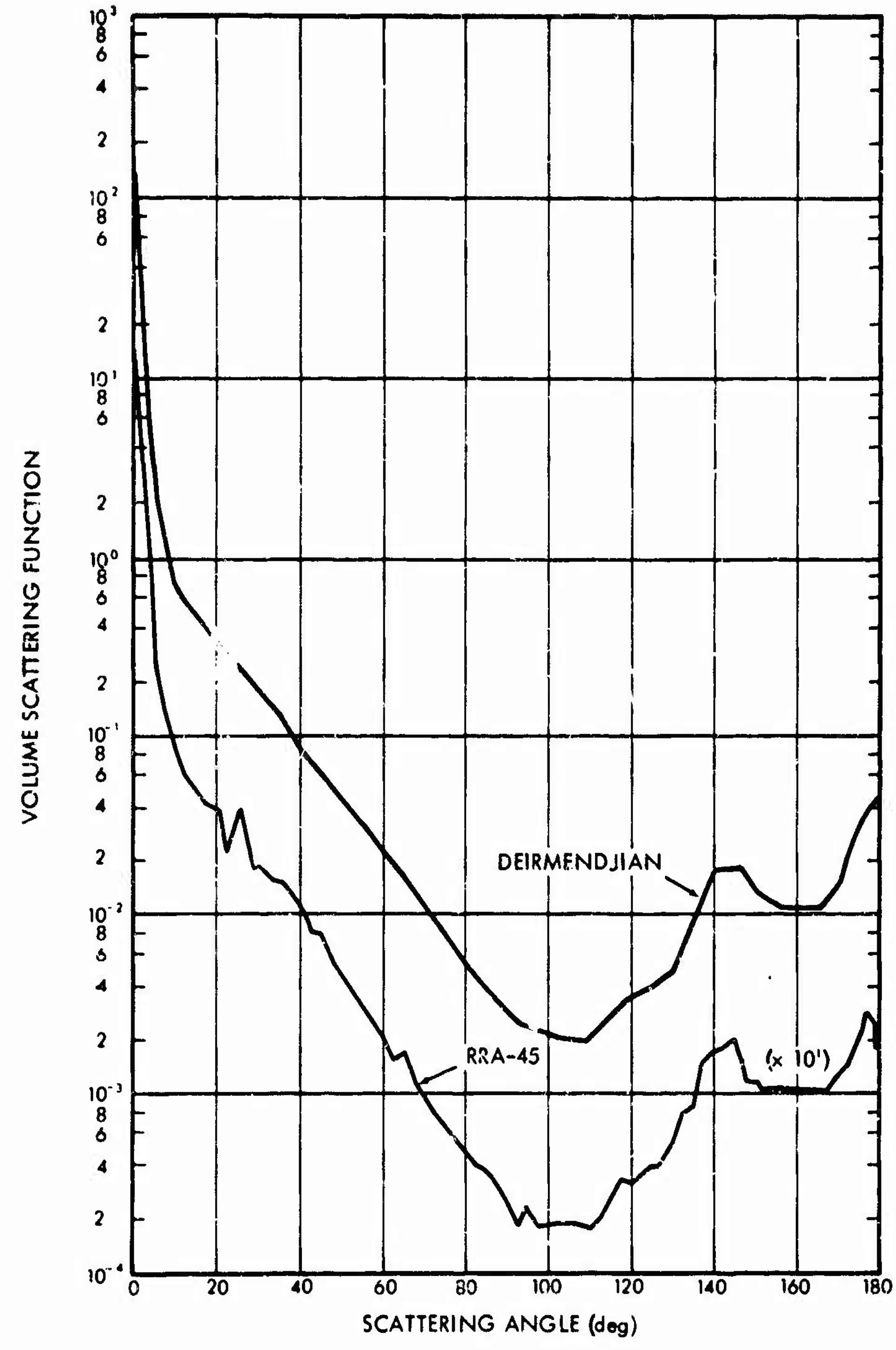


Fig. 15. Volume Scattering Function for Cloud Model vs Scattering Angle: $\lambda = 0.70\mu$, $m = 1.33$

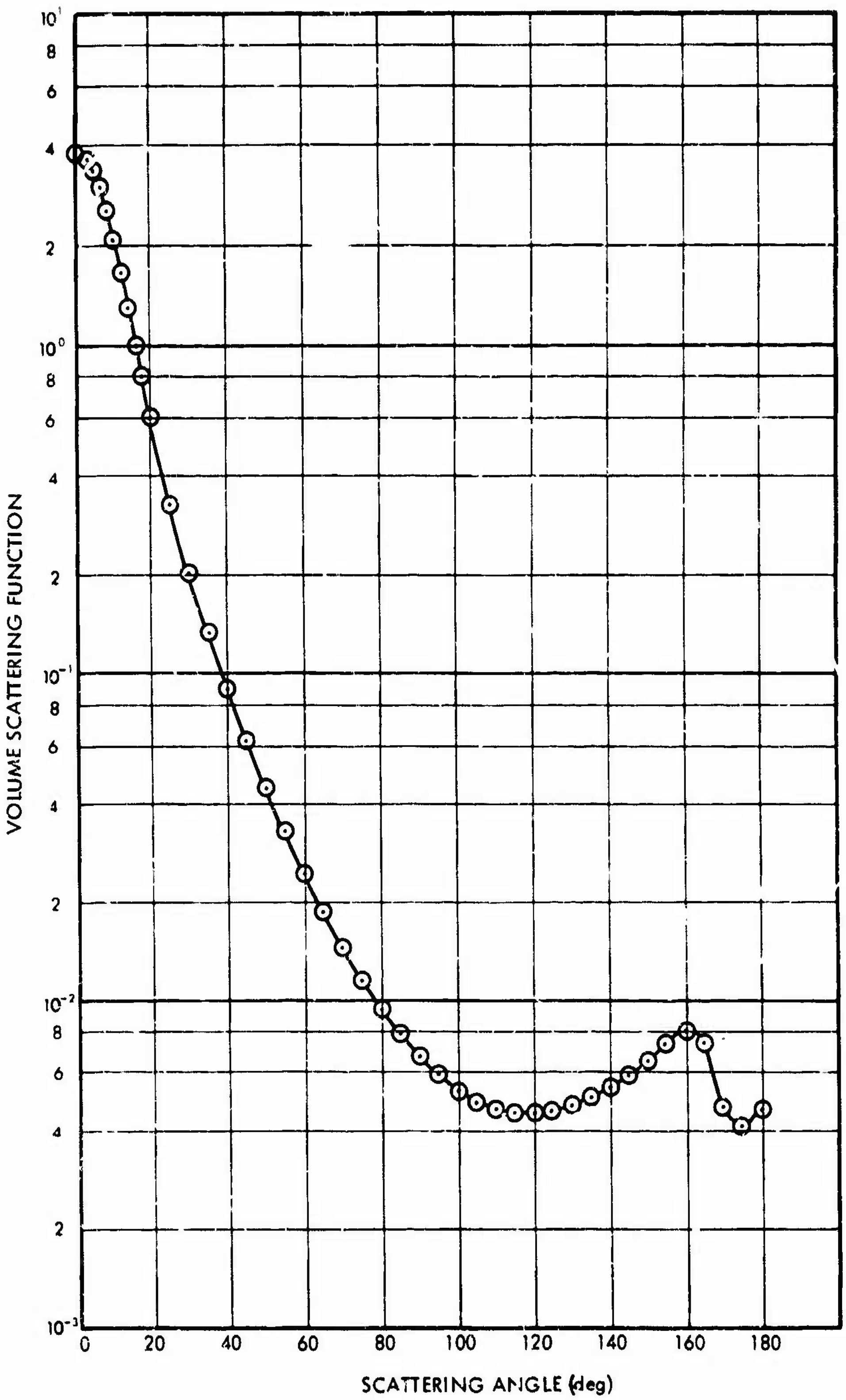


Fig. 16. Volume Scattering Function for Cloud Model vs Scattering Angle: $\lambda = 5.3\mu$, m = 1.315-0.0143i

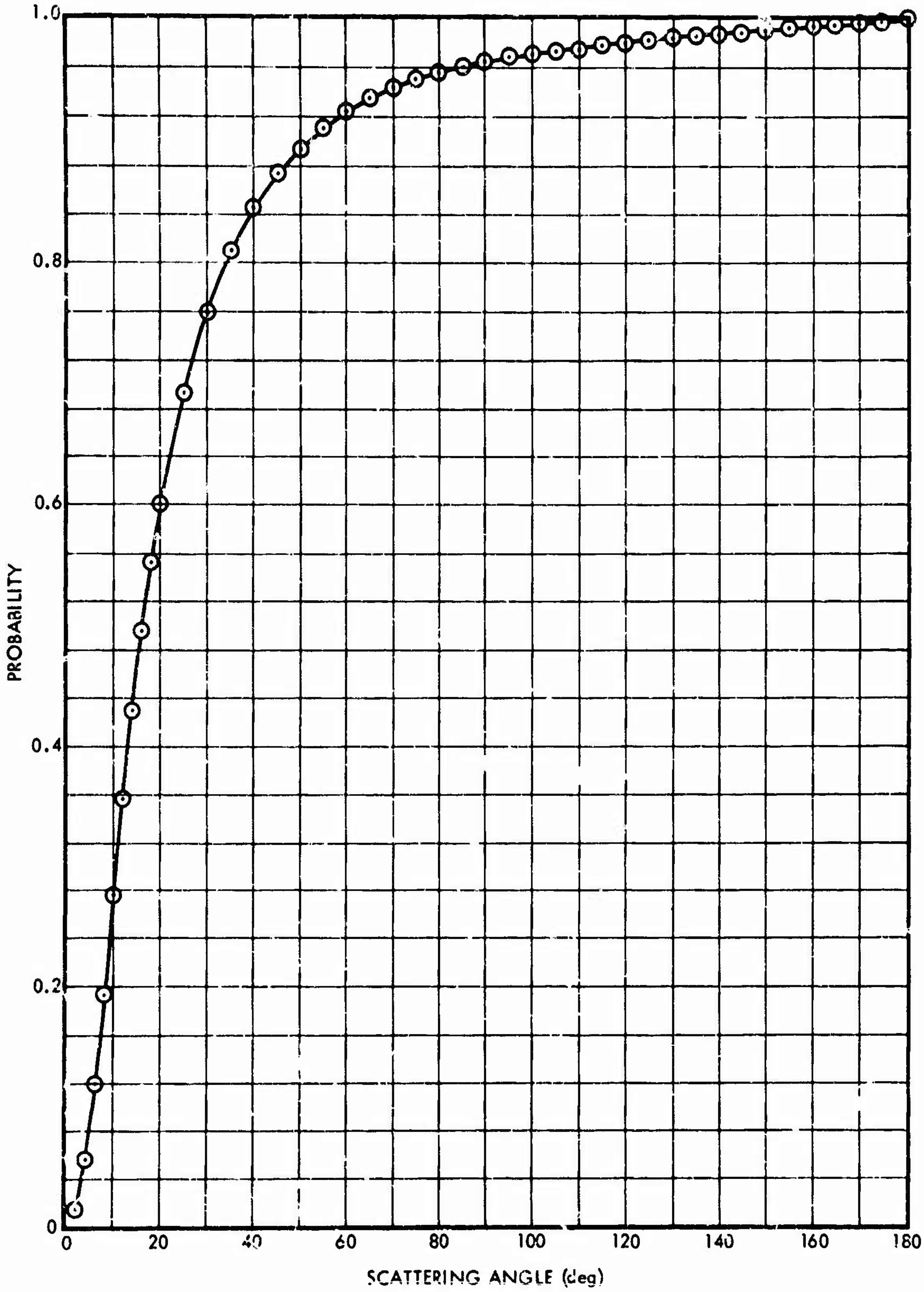


Fig. 17. Cumulative Scattering Probability vs Scattering Angle for Cloud Model: $\lambda = 5.3\mu$, $m = 1.315-0.0143i$

The small differences seen between Deirmendjian's results and the RRA-45 calculations are probably due to the use of different integration schemes. RRA-45 performs the integration of the cross-section data by fitting a quadratic curve to three data points and integrating this curve analytically. Figures 18 and 19 show plots of the extinction cross section for the Haze M, Haze C and cloud models and for the two refractive indices, 1.33 and 1.50. These values shown in the figures represent the cross section for 100 particles per $cm^3$ for the Haze M and cloud models and 2300 particles per $cm^3$ for the Haze C model. As would be expected from the white appearance of cumulus clouds, the extinction cross section for the cloud is almost independent of the wave length in the visible wave lengths. The shape of the curve for the continental haze, Haze C, illustrates the predominance of red transmitted light, as observed with sunlight transmission through land hazes. The sunlight transmitted through a Haze M type water haze should have a bluish-white appearance.

Figure 20 shows the extinction cross section plotted as a function of wave length for the five power-law distributions. The total particle density was taken to be 2300 $cm^{-3}$. Upper and lower bounds for the particle radius were taken to be 10μ and .03μ in all five cases. The refractive index was 1.50.

The Haze M and cloud model size distribution curves decrease very rapidly as the radius increases, so that the integrals over these distributions are fairly insensitive to the upper bound, as long as this upper bound is fairly large in comparison with the mode radius. However, the power-law distributions, including the Haze C distributions, exhibit

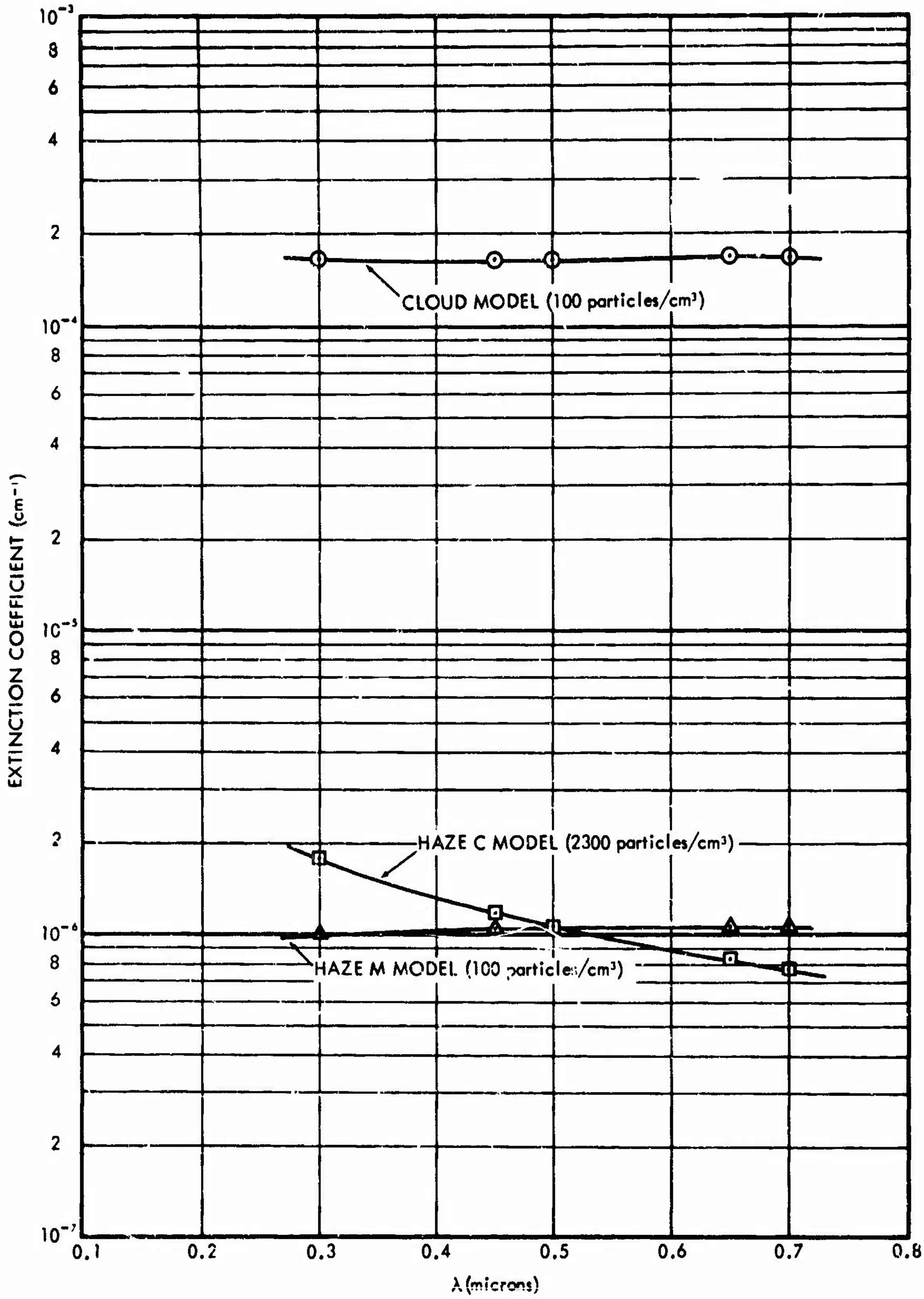


Fig. 18. Extinction Coefficient vs Wavelength for Haze C, Haze M, and Cloud Models: m = 1.33

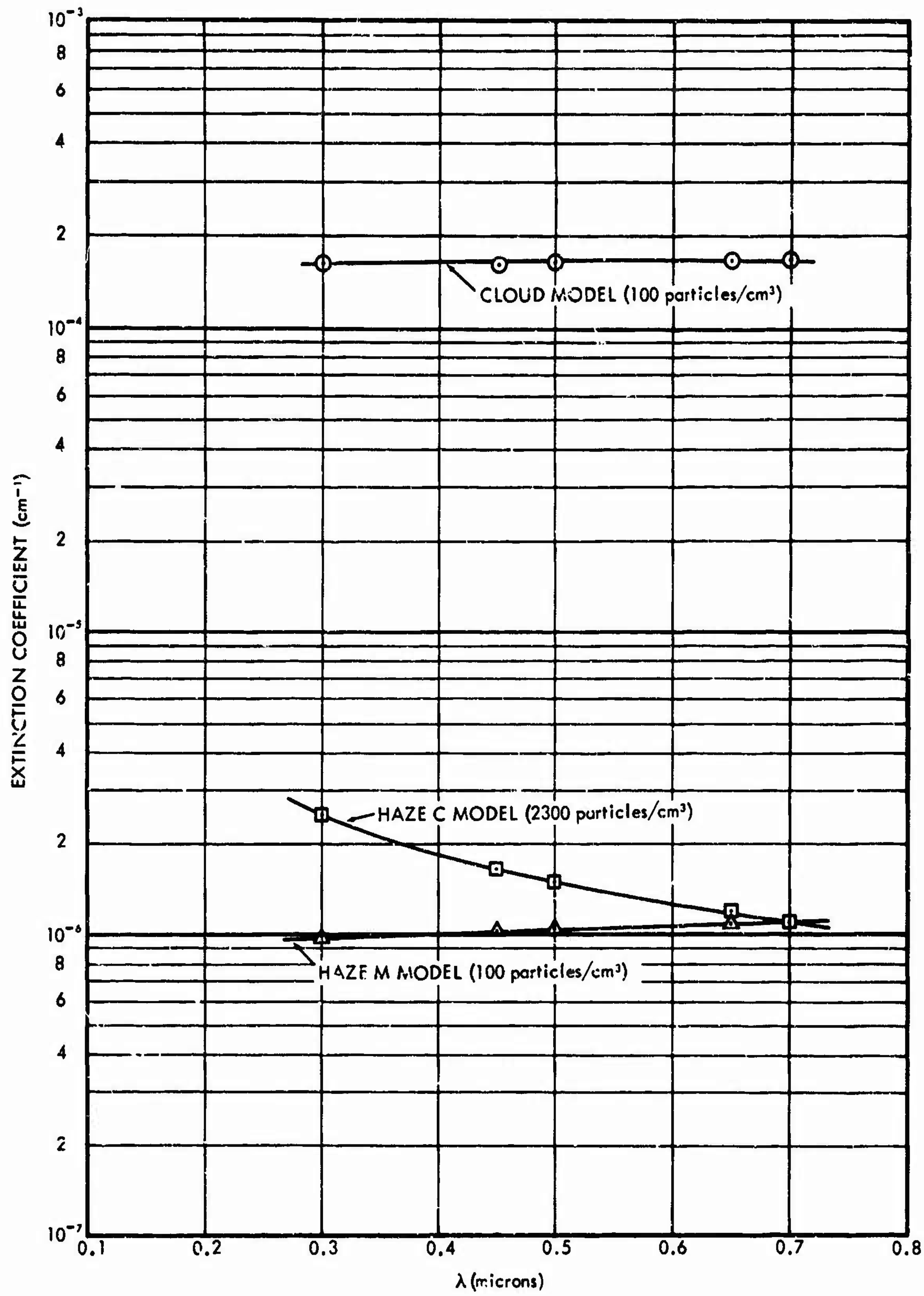


Fig. 19. Extinction Coefficient vs Wavelength for Haze C, Haze M, and Cloud Models: m = 1.50

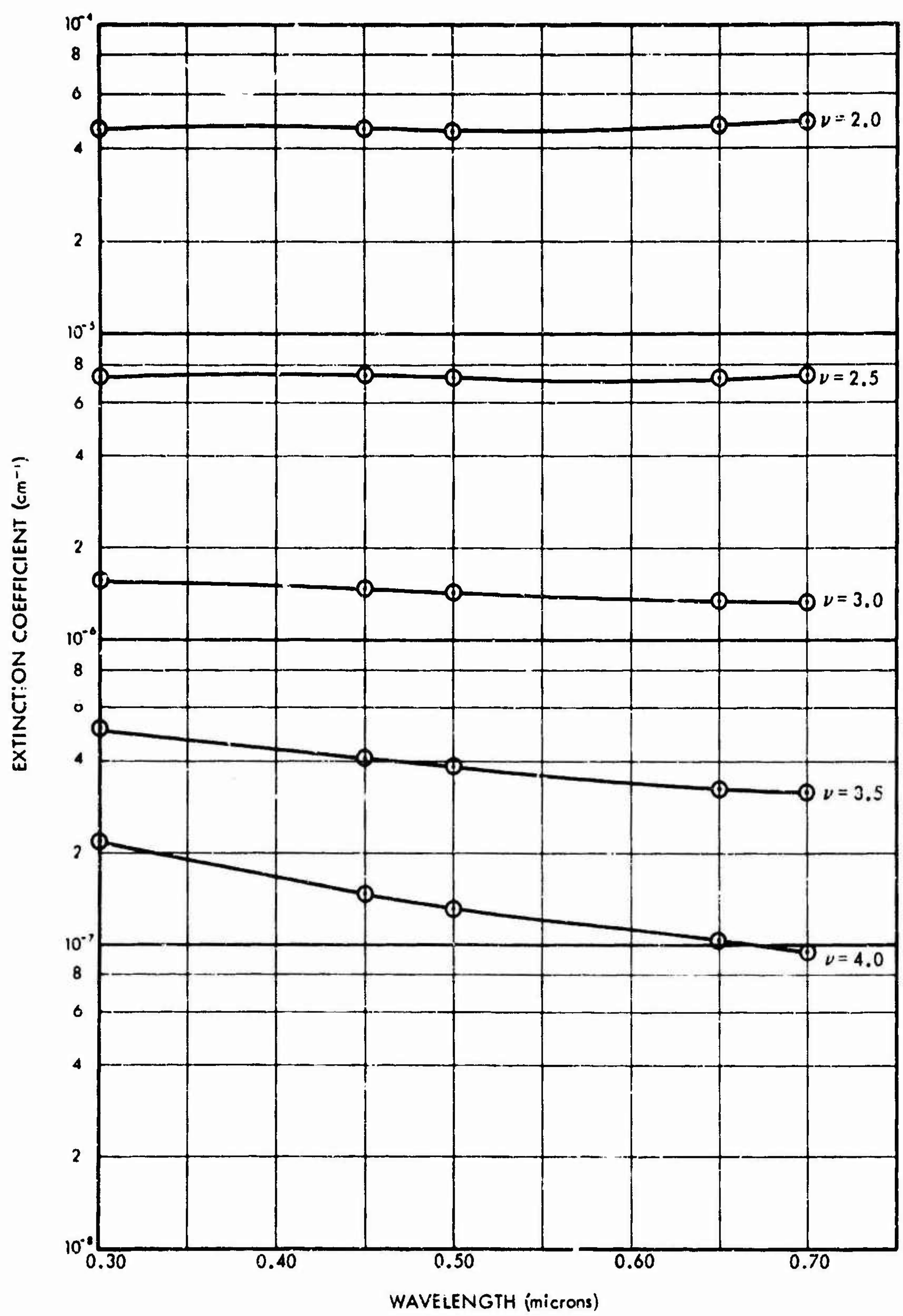


Fig. 20. Extinction Coefficient vs Wavelength for Several Values of $\nu$: m = 1.50

varying degrees of dependence upon the upper bound of the integral. The dependence of the integrals on the value of the lower bound is not as large as the dependence on the value of the upper bound. Figure 21 shows the dependence of the extinction coefficient on both the upper bound of the particle radius and $\nu$ for the $r^{-\nu}$ size distributions when $\lambda = .30\mu$. The particle density for the values shown is 2300 $cm^{-3}$. The lower curve was obtained by integrating up to $6\mu$, while the upper curve was calculated with an upper bound of $10\mu$. It can be seen that only for $\nu = 4$ is the integration insensitive to any degree to the upper bound for $r > 6$ microns.

As was stated earlier, the size of the integration increment for the size parameter, when integrating over the microscopic data, shows a greater effect upon the phase function or volume scattering function than it does upon the scattering and extinction cross sections. Original investigations to determine the increment in the size parameter to be used when generating the basic Mie data with RRA-42 were undertaken with the principal parameters studied being the cross sections. This led to a somewhat larger increment than was warranted for the phase function calculations. This was overlooked in the preliminary calculations since these first calculations involved the Haze C model. This model exhibited good definition in the phase function, since most of the size parameters used in the integrations are small with this model, and the microscopic phase functions are all fairly similar and smooth. The effect of this lack of definition may be noted for the extreme case shown in Figure 15. The calculated volume scattering function by Deirmendjian (Ref. 4) was obtained by integrating over extremely small size increments. The size parameter increment for the curve calculated by

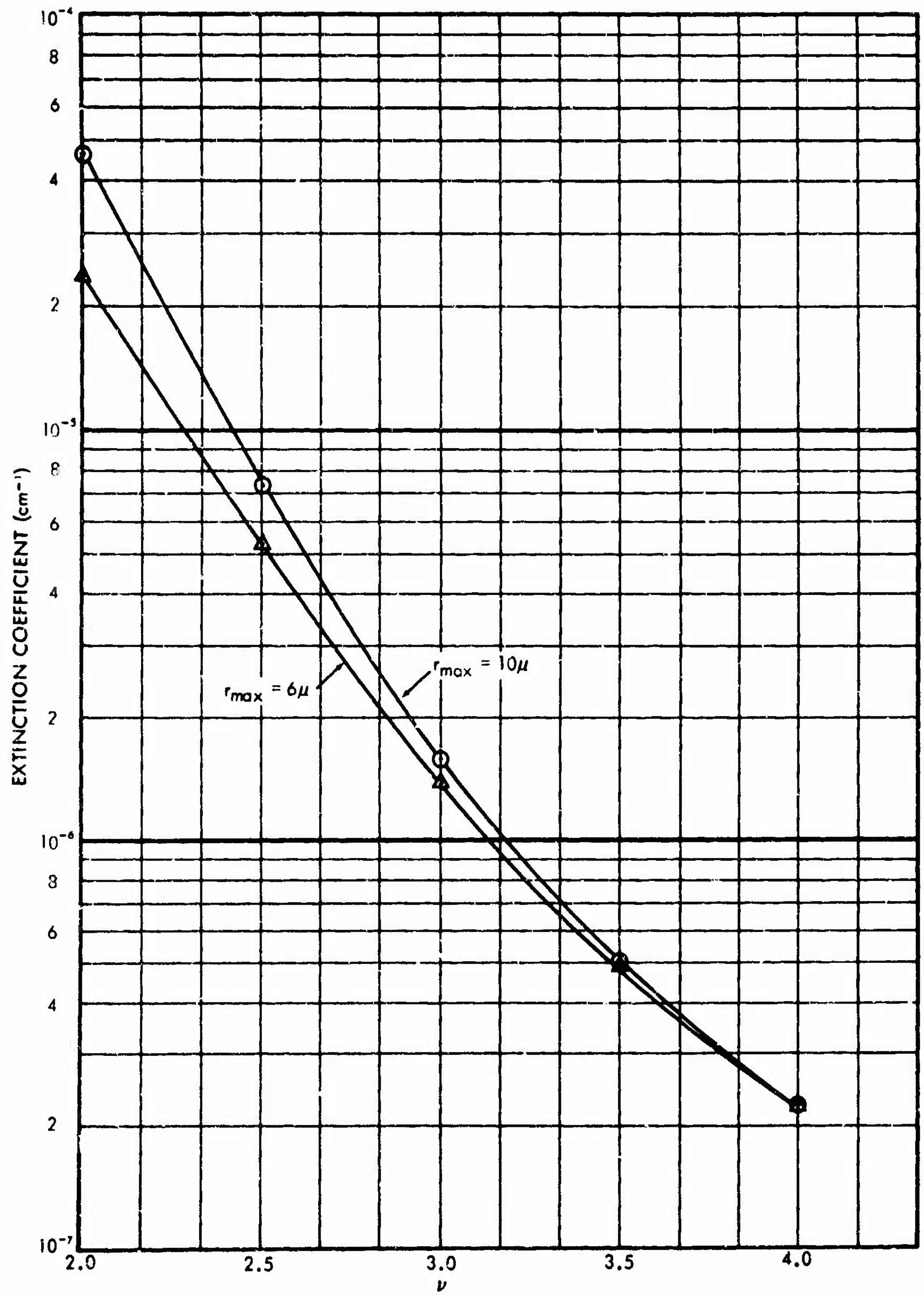


Fig. 21. Variation of the Extinction Coefficient with $\nu$ for $r_{max} = 6$ and $10\mu$ : $\lambda = 0.30\mu$, $m = 1.50$

RRA-45 was several times larger. Of course, some of the differences seen in Figure 15 may be due to differences in the integration methods used. Also, the RRA-45 curve was evaluated at smaller angular increments. Some elementary smoothing of the lower curve would produce good agreement with Deirmendjian's calculations.

Table II contains the extinction coefficients for the eight size distributions discussed; Haze M, Haze C, cloud and $\nu$ = 2, 2.5, 3, 3.5, 4 and for wave lengths 0.3, 0.45, 0.5, 0.65, and 0.70 microns.

A tabulation of the normalized phase functions for natural light, as defined in Equation 28, is given in Table III.

Table IV shows the average cosine, as defined in Equation 30, for the size distributions and wave lengths listed above.

Table II. Macroscopic Extinction Cross Section for Various Aerosol Particle Size Distributions

($cm^{-1}$/particle $cm^{-3}$)

| Index of Refraction | Aerosol Model | Wave Length (μ) | | | | |
|---|---|---|---|---|---|---|
| | | 0.30 | 0.45 | 0.50 | 0.65 | 0.70 |
| 1.5 | Cloud | 1.632-06* | 1.651-06 | 1.658-06 | 1.676-06 | 1.679-06 |
| 1.5 | Haze C | 1.090-09 | 7.239-10 | 6.574-10 | 5.200-10 | 4.891-10 |
| 1.5 | Haze M | 9.905-09 | 1.048-08 | 1.063-08 | 1.093-08 | 1.101-08 |
| 1.5 | $\nu$ = 2.0 | 2.021-08 | 2.050-08 | 1.967-08 | 2.042-08 | 2.091-08 |
| 1.5 | $\nu$ = 2.5 | 3.201-09 | 3.203-09 | 3.125-09 | 3.155-09 | 3.187-09 |
| 1.5 | $\nu$ = 3.0 | 6.817-10 | 6.370-10 | 6.191-10 | 5.887-10 | 5.826-10 |
| 1.5 | $\nu$ = 3.5 | 2.204-10 | 1.785-10 | 1.681-10 | 1.448-10 | 1.391-10 |
| 1.5 | $\nu$ = 4.0 | 9.661-11 | 6.522-11 | 5.861-11 | 4.470-11 | 4.146-11 |
| 1.33 | Cloud | 1.649-06 | 1.669-06 | 1.677-06 | 1.706-06 | 1.641-06 |
| 1.33 | Haze C | 7.739-10 | 5.091-10 | 4.600-10 | 3.621-10 | 3.386-10 |
| 1.33 | Haze M | 1.018-08 | 1.051-08 | 1.06 -08 | 1.063-08 | 1.054-08 |

* Read 1.632-06 as $1.632 \times 10^{-6}$

TABLE III-A. NORMALIZED VOLUME SCATTERING FUNCTION: CLOUD MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 7.264E 02 | 3.269E 02 | 2.653E 02 | 1.587E 02 | 1.343E 02 |
| 1.0 | 1.350E 02 | 1.432E 02 | 1.347E 02 | 1.054E 02 | 9.270E 01 |
| 2.0 | 9.811E 00 | 2.255E 01 | 2.711E 01 | 3.628E 01 | 3.411E 01 |
| 3.0 | 3.747E 00 | 5.302E 00 | 6.262E 00 | 1.008E 01 | 9.596E 00 |
| 4.0 | 2.310E 00 | 2.769E 00 | 2.892E 00 | 3.677E 00 | 3.705E 00 |
| 5.0 | 1.132E 00 | 1.489E 00 | 1.582E 00 | 1.872E 00 | 2.290E 00 |
| 6.0 | 8.381E-01 | 9.507E-01 | 1.023E 00 | 1.211E 00 | 1.664E 00 |
| 7.0 | 9.150E-01 | 9.912E-01 | 9.917E-01 | 9.960E-01 | 1.279E 00 |
| 8.0 | 7.933E-01 | 8.721E-01 | 8.758E-01 | 8.693E-01 | 1.032E 00 |
| 9.0 | 6.172E-01 | 6.791E-01 | 7.074E-01 | 7.585E-01 | 8.528E-01 |
| 10.0 | 6.189E-01 | 6.609E-01 | 6.710E-01 | 6.939E-01 | 7.353E-01 |
| 11.0 | 5.417E-01 | 5.637E-01 | 5.813E-01 | 6.243E-01 | 6.561E-01 |
| 12.0 | 5.440E-01 | 5.672E-01 | 5.676E-01 | 5.775E-01 | 5.899E-01 |
| 13.0 | 4.909E-01 | 5.198E-01 | 5.250E-01 | 5.368E-01 | 5.453E-01 |
| 14.0 | 5.051E-01 | 4.861E-01 | 4.872E-01 | 4.993E-01 | 5.026E-01 |
| 15.0 | 4.277E-01 | 4.526E-01 | 4.561E-01 | 4.673E-01 | 4.691E-01 |
| 16.0 | 4.261E-01 | 4.238E-01 | 4.248E-01 | 4.275E-01 | 4.530E-01 |
| 17.0 | 3.974E-01 | 4.019E-01 | 4.021E-01 | 4.024E-01 | 4.286E-01 |
| 18.0 | 3.755E-01 | 3.825E-01 | 3.846E-01 | 3.900E-01 | 3.977E-01 |
| 19.0 | 3.586E-01 | 3.599E-01 | 3.594E-01 | 3.651E-01 | 3.900E-01 |
| 20.0 | 3.418E-01 | 3.392E-01 | 3.398E-01 | 3.527E-01 | 3.876E-01 |
| 22.5 | 2.995E-01 | 3.029E-01 | 2.870E-01 | 2.236E-01 | 2.135E-01 |
| 25.0 | 3.510E-01 | 3.724E-01 | 3.758E-01 | 3.810E-01 | 3.977E-01 |
| 27.5 | 2.139E-01 | 2.235E-01 | 2.196E-01 | 1.847E-01 | 1.832E-01 |
| 30.0 | 1.812E-01 | 1.797E-01 | 1.795E-01 | 1.836E-01 | 1.958E-01 |
| 32.5 | 1.538E-01 | 1.567E-01 | 1.571E-01 | 1.578E-01 | 1.635E-01 |
| 35.0 | 1.191E-01 | 1.285E-01 | 1.306E-01 | 1.322E-01 | 1.395E-01 |
| 37.5 | 1.150E-01 | 1.189E-01 | 1.183E-01 | 1.162E-01 | 1.210E-01 |
| 40.0 | 9.613E-02 | 9.829E-02 | 9.800E-02 | 9.702E-02 | 1.010E-01 |
| 42.5 | 7.449E-02 | 7.499E-02 | 7.677E-02 | 8.234E-02 | 8.084E-02 |
| 45.0 | 7.838E-02 | 6.531E-02 | 6.234E-02 | 5.834E-02 | 7.978E-02 |
| 47.5 | 5.026E-02 | 4.94[illegible]E-02 | 5.084E-02 | 5.565E-02 | 5.513E-02 |
| 50.0 | 4.403E-02 | 4.340E-02 | 4.353E-02 | 4.412E-02 | 4.699E-02 |
| 52.5 | 3.531E-02 | 3.562E-02 | 3.589E-02 | 3.696E-02 | 3.893E-02 |
| 55.0 | 2.488E-02 | 2.706E-02 | 2.776E-02 | 2.935E-02 | 3.066E-02 |
| 57.5 | 2.175E-02 | 2.259E-02 | 2.289E-02 | 2.406E-02 | 2.585E-02 |
| 60.0 | 1.677E-02 | 1.820E-02 | 1.864E-02 | 2.001E-02 | 2.126E-02 |
| 62.5 | 1.467E-02 | 1.570E-02 | 1.525E-02 | 1.355E-02 | 1.399E-02 |
| 65.0 | 1.148E-02 | 1.478E-02 | 1.562E-02 | 1.767E-02 | 1.886E-02 |
| 67.5 | 9.070E-03 | 1.036E-02 | 1.077E-02 | 1.107E-02 | 1.154E-02 |
| 70.0 | 7.433E-03 | 8.166E-03 | 8.344E-03 | 9.019E-03 | 1.006E-02 |
| 72.5 | 6.204E-03 | 6.863E-03 | 7.061E-03 | 7.716E-03 | 8.083E-03 |
| 75.0 | 4.943E-03 | 5.530E-03 | 5.723E-03 | 6.204E-03 | 6.750E-03 |
| 77.5 | 3.943E-03 | 4.580E-03 | 4.768E-03 | 5.331E-03 | 5.891E-03 |
| 80.0 | 3.173E-03 | 3.676E-03 | 3.883E-03 | 4.529E-03 | 5.049E-03 |
| 82.5 | 2.933E-03 | 3.543E-03 | 3.721E-03 | 4.197E-03 | 4.116E-03 |
| 85.0 | 2.319E-03 | 2.755E-03 | 2.891E-03 | 3.309E-03 | 3.892E-03 |
| 87.5 | 2.030E-03 | 2.300E-03 | 2.447E-03 | 3.006E-03 | 3.288E-03 |
| 90.0 | 1.478E-03 | 1.976E-03 | 2.139E-03 | 2.640E-03 | 2.734E-03 |
| 92.5 | 1.436E-03 | 1.757E-03 | 1.791E-03 | 1.825E-03 | 1.874E-03 |

TABLE III-A. NORMALIZED VOLUME SCATTERING FUNCTION: CLOUD MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.207E-03 | 1.678E-03 | 1.836E-03 | 2.275E-03 | 2.380E-03 |
| 97.5 | 1.272E-03 | 1.578E-03 | 1.662E-03 | 1.890E-03 | 1.811E-03 |
| 100.0 | 1.155E-03 | 1.595E-03 | 1.725E-03 | 2.004E-03 | 1.975E-03 |
| 102.5 | 1.161E-03 | 1.556E-03 | 1.636E-03 | 1.720E-03 | 1.818E-03 |
| 105.0 | 1.513E-03 | 1.646E-03 | 1.672E-03 | 1.831E-03 | 1.781E-03 |
| 107.5 | 1.288E-03 | 1.303E-03 | 1.339E-03 | 1.486E-03 | 1.901E-03 |
| 110.0 | 1.914E-03 | 1.676E-03 | 1.673E-03 | 1.918E-03 | 1.690E-03 |
| 112.5 | 1.633E-03 | 1.792E-03 | 1.857E-03 | 2.102E-03 | 2.073E-03 |
| 115.0 | 1.474E-03 | 1.879E-03 | 2.067E-03 | 2.539E-03 | 2.612E-03 |
| 117.5 | 2.045E-03 | 2.359E-03 | 2.387E-03 | 2.417E-03 | 3.400E-03 |
| 120.0 | 2.632E-03 | 2.717E-03 | 2.716E-03 | 2.784E-03 | 3.132E-03 |
| 122.5 | 3.437E-03 | 3.443E-03 | 3.375E-03 | 3.159E-03 | 3.498E-03 |
| 125.0 | 3.329E-03 | 3.285E-03 | 3.396E-03 | 3.785E-03 | 4.017E-03 |
| 127.5 | 3.451E-03 | 3.473E-03 | 3.547E-03 | 3.893E-03 | 4.063E-03 |
| 130.0 | 3.525E-03 | 4.244E-03 | 4.445E-03 | 5.115E-03 | 5.232E-03 |
| 132.5 | 4.688E-03 | 5.628E-03 | 5.745E-03 | 5.957E-03 | 7.818E-03 |
| 135.0 | 8.000E-03 | 9.478E-03 | 9.866E-03 | 1.081E-02 | 8.624E-03 |
| 137.5 | 1.659E-02 | 1.490E-02 | 1.455E-02 | 1.377E-02 | 1.421E-02 |
| 140.0 | 2.299E-02 | 1.962E-02 | 1.896E-02 | 1.670E-02 | 1.671E-02 |
| 142.5 | 1.845E-02 | 1.850E-02 | 1.830E-02 | 1.776E-02 | 1.865E-02 |
| 145.0 | 1.158E-02 | 1.689E-02 | 1.808E-02 | 2.016E-02 | 2.159E-02 |
| 147.5 | 1.077E-02 | 1.013E-02 | 1.023E-02 | 1.101E-02 | 1.184E-02 |
| 150.0 | 1.095E-02 | 1.090E-02 | 1.093E-02 | 1.143E-02 | 1.211E-02 |
| 152.5 | 9.471E-03 | 9.529E-03 | 9.507E-03 | 9.670E-03 | 1.027E-02 |
| 155.0 | 8.748E-03 | 9.736E-03 | 1.006E-02 | 1.089E-02 | 1.160E-02 |
| 156.0 | 9.752E-03 | 9.357E-03 | 9.138E-03 | 8.865E-03 | 9.508E-03 |
| 157.0 | 8.018E-03 | 8.354E-03 | 8.468E-03 | 8.806E-03 | 9.583E-03 |
| 158.0 | 8.939E-03 | 9.690E-03 | 9.874E-03 | 1.051E-02 | 1.129E-02 |
| 159.0 | 7.983E-03 | 8.993E-03 | 9.462E-03 | 1.100E-02 | 1.158E-02 |
| 160.0 | 8.592E-03 | 8.840E-03 | 9.034E-03 | 1.032E-02 | 1.025E-02 |
| 161.0 | 7.870E-03 | 8.559E-03 | 8.774E-03 | 9.437E-03 | 9.687E-03 |
| 162.0 | 7.589E-03 | 8.140E-03 | 8.247E-03 | 8.571E-03 | 1.093E-02 |
| 163.0 | 7.836E-03 | 8.651E-03 | 8.866E-03 | 9.389E-03 | 1.012E-02 |
| 164.0 | 7.762E-03 | 8.683E-03 | 9.034E-03 | 1.003E-02 | 9.731E-03 |
| 165.0 | 7.514E-03 | 8.311E-03 | 8.584E-03 | 9.354E-03 | 1.045E-02 |
| 166.0 | 7.852E-03 | 8.503E-03 | 8.647E-03 | 9.009E-03 | 1.077E-02 |
| 167.0 | 7.503E-03 | 8.150E-03 | 8.380E-03 | 9.160E-03 | 1.050E-02 |
| 168.0 | 6.564E-03 | 7.666E-03 | 8.194E-03 | 9.759E-03 | 1.041E-02 |
| 169.0 | 8.239E-03 | 9.086E-03 | 9.444E-03 | 1.082E-02 | 1.096E-02 |
| 170.0 | 7.082E-03 | 9.284E-03 | 9.888E-03 | 1.160E-02 | 1.234E-02 |
| 171.0 | 7.751E-03 | 8.971E-03 | 9.471E-03 | 1.122E-02 | 1.366E-02 |
| 172.0 | 7.339E-03 | 9.148E-03 | 9.638E-03 | 1.128E-02 | 1.393E-02 |
| 173.0 | 8.547E-03 | 1.028E-02 | 1.090E-02 | 1.309E-02 | 1.434E-02 |
| 174.0 | 9.123E-03 | 1.132E-02 | 1.212E-02 | 1.520E-02 | 1.614E-02 |
| 175.0 | 1.014E-02 | 1.252E-02 | 1.355E-02 | 1.787E-02 | 2.005E-02 |
| 176.0 | 1.074E-02 | 1.432E-02 | 1.609E-02 | 2.247E-02 | 2.600E-02 |
| 177.0 | 1.362E-02 | 2.001E-02 | 2.251E-02 | 2.760E-02 | 3.063E-02 |
| 178.0 | 2.139E-02 | 2.794E-02 | 2.770E-02 | 2.375E-02 | 2.504E-02 |
| 179.0 | 2.419E-02 | 1.618E-02 | 1.511E-02 | 1.432E-02 | 1.738E-02 |
| 180.0 | 3.760E-02 | 2.568E-02 | 2.239E-02 | 1.813E-02 | 2.239E-02 |

TABLE III-B. NORMALIZED VOLUME SCATTERING FUNCTION: CLOUD MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 7.210E 02 | 3.239E 02 | 2.630E 02 | 1.570E 02 | 1.353E 02 |
| 1.0 | 1.288E 02 | 1.397E 02 | 1.318E 02 | 1.032E 02 | 9.412E 01 |
| 2.0 | 1.082E 01 | 2.144E 01 | 2.557E 01 | 3.418E 01 | 3.552E 01 |
| 3.0 | 3.572E 00 | 5.171E 00 | 5.902E 00 | 9.045E 00 | 1.034E 01 |
| 4.0 | 1.807E 00 | 2.370E 00 | 2.554E 00 | 3.295E 00 | 3.748E 00 |
| 5.0 | 9.579E-01 | 1.330E 00 | 1.452E 00 | 1.817E 00 | 2.042E 00 |
| 6.0 | 7.405E-01 | 9.092E-01 | 9.805E-01 | 1.244E 00 | 1.393E 00 |
| 7.0 | 6.223E-01 | 7.417E-01 | 7.808E-01 | 9.426E-01 | 1.024E 00 |
| 8.0 | 4.835E-01 | 5.634E-01 | 6.064E-01 | 7.173E-01 | 7.522E-01 |
| 9.0 | 4.673E-01 | 5.760E-01 | 6.023E-01 | 5.693E-01 | 5.376E-01 |
| 10.0 | 4.269E-01 | 4.468E-01 | 4.142E-01 | 2.986E-01 | 2.652E-01 |
| 11.0 | 3.852E-01 | 2.197E-01 | 1.930E-01 | 2.028E-01 | 2.117E-01 |
| 12.0 | 2.301E-01 | 3.612E-01 | 3.981E-01 | 4.897E-01 | 5.028E-01 |
| 13.0 | 5.164E-01 | 5.912E-01 | 6.101E-01 | 6.562E-01 | 6.595E-01 |
| 14.0 | 2.160E-01 | 2.498E-01 | 2.875E-01 | 4.023E-01 | 4.272E-01 |
| 15.0 | 3.245E-01 | 2.510E-01 | 2.260E-01 | 2.094E-01 | 2.110E-01 |
| 16.0 | 3.077E-01 | 3.206E-01 | 3.076E-01 | 2.391E-01 | 2.249E-01 |
| 17.0 | 2.891E-01 | 3.001E-01 | 3.029E-01 | 2.899E-01 | 2.844E-01 |
| 18.0 | 2.580E-01 | 2.697E-01 | 2.772E-01 | 2.984E-01 | 2.839E-01 |
| 19.0 | 2.618E-01 | 2.644E-01 | 2.672E-01 | 2.811E-01 | 2.789E-01 |
| 20.0 | 2.496E-01 | 2.527E-01 | 2.546E-01 | 2.609E-01 | 2.670E-01 |
| 22.5 | 2.356E-01 | 2.339E-01 | 2.321E-01 | 2.277E-01 | 2.325E-01 |
| 25.0 | 1.831E-01 | 1.886E-01 | 1.915E-01 | 1.968E-01 | 2.146E-01 |
| 27.5 | 1.825E-01 | 1.849E-01 | 1.858E-01 | 1.867E-01 | 1.950E-01 |
| 30.0 | 1.811E-01 | 1.841E-01 | 1.832E-01 | 1.817E-01 | 1.780E-01 |
| 32.5 | 1.568E-01 | 1.549E-01 | 1.522E-01 | 1.476E-01 | 1.478E-01 |
| 35.0 | 1.432E-01 | 1.418E-01 | 1.437E-01 | 1.444E-01 | 1.193E-01 |
| 37.5 | 1.299E-01 | 1.238E-01 | 1.239E-01 | 1.217E-01 | 1.106E-01 |
| 40.0 | 1.167E-01 | 1.144E-01 | 1.110E-01 | 1.031E-01 | 1.047E-01 |
| 42.5 | 9.825E-02 | 9.885E-02 | 9.767E-02 | 9.300E-02 | 9.476E-02 |
| 45.0 | 8.148E-02 | 8.286E-02 | 8.397E-02 | 8.502E-02 | 8.539E-02 |
| 47.5 | 7.675E-02 | 7.535E-02 | 7.507E-02 | 7.527E-02 | 7.356E-02 |
| 50.0 | 6.213E-02 | 6.285E-02 | 6.320E-02 | 6.376E-02 | 6.908E-02 |
| 52.5 | 5.746E-02 | 5.669E-02 | 5.724E-02 | 6.079E-02 | 6.229E-02 |
| 55.0 | 5.365E-02 | 4.817E-02 | 4.490E-02 | 3.928E-02 | 3.861E-02 |
| 57.5 | 3.221E-02 | 3.936E-02 | 4.268E-02 | 5.107E-02 | 5.219E-02 |
| 60.0 | 3.870E-02 | 3.963E-02 | 4.003E-02 | 4.053E-02 | 4.012E-02 |
| 62.5 | 3.491E-02 | 3.334E-02 | 3.291E-02 | 3.274E-02 | 3.366E-02 |
| 65.0 | 2.728E-02 | 2.925E-02 | 3.047E-02 | 3.361E-02 | 3.441E-02 |
| 67.5 | 2.272E-02 | 2.372E-02 | 2.393E-02 | 2.474E-02 | 2.534E-02 |
| 70.0 | 2.045E-02 | 2.114E-02 | 2.106E-02 | 2.088E-02 | 2.121E-02 |
| 72.5 | 1.755E-02 | 1.862E-02 | 1.901E-02 | 2.009E-02 | 2.049E-02 |
| 75.0 | 1.637E-02 | 1.739E-02 | 1.748E-02 | 1.798E-02 | 1.640E-02 |
| 77.5 | 1.102E-02 | 1.270E-02 | 1.311E-02 | 1.390E-02 | 1.456E-02 |
| 80.0 | 1.068E-02 | 1.162E-02 | 1.211E-02 | 1.369E-02 | 1.401E-02 |
| 82.5 | 1.042E-02 | 1.218E-02 | 1.248E-02 | 1.277E-02 | 1.320E-02 |
| 85.0 | 9.634E-03 | 1.201E-02 | 1.266E-02 | 1.354E-02 | 1.063E-02 |
| 87.5 | 1.083E-02 | 1.206E-02 | 1.208E-02 | 1.208E-02 | 1.050E-02 |
| 90.0 | 7.708E-03 | 8.144E-03 | 8.341E-03 | 8.716E-03 | 8.971E-03 |
| 92.5 | 6.409E-03 | 7.111E-03 | 7.442E-03 | 8.529E-03 | 8.317E-03 |

TABLE III-B. NORMALIZED VOLUME SCATTERING FUNCTION: CLOUD MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 4.638E-03 | 5.653E-03 | 5.830E-03 | 6.027E-03 | 5.882E-03 |
| 97.5 | 4.601E-03 | 5.407E-03 | 5.531E-03 | 5.902E-03 | 6.228E-03 |
| 100.0 | 3.285E-03 | 3.934E-03 | 4.134E-03 | 4.625E-03 | 4.909E-03 |
| 102.5 | 2.620E-03 | 3.135E-03 | 3.238E-03 | 3.472E-03 | 3.714E-03 |
| 105.0 | 2.589E-03 | 2.899E-03 | 3.005E-03 | 3.483E-03 | 3.885E-03 |
| 107.5 | 3.326E-03 | 3.293E-03 | 3.241E-03 | 3.255E-03 | 2.851E 03 |
| 110.0 | 2.244E-03 | 3.011E-03 | 3.306E-03 | 3.872E-03 | 3.845[illegible]03 |
| 112.5 | 2.552E-03 | 2.781E-03 | 2.851E-03 | 3.141E-03 | 2.97[illegible]-03 |
| 115.0 | 2.979E-03 | 3.306E-03 | 3.358E-03 | 3.562E-03 | 3.312E-03 |
| 117.5 | 2.422E-03 | 2.864E-03 | 2.966E-03 | 3.072E-03 | 3.016E-03 |
| 120.0 | 2.717E-03 | 2.906E-03 | 3.001E-03 | 3.119E-03 | 2.570E-03 |
| 122.5 | 2.107E-03 | 2.503E-03 | 2.653E-03 | 2.973E-03 | 2.849E-03 |
| 125.0 | 2.064E-03 | 2.361E-03 | 2.448E-03 | 2.620E-03 | 2.671E-03 |
| 127.5 | 1.975E-03 | 2.121E-03 | 2.216E-03 | 2.473E-03 | 2.324E-03 |
| 130.0 | 1.788E-03 | 1.972E-03 | 2.115E-03 | 2.566E-03 | 2.603E-03 |
| 132.5 | 2.445E-03 | 2.319E-03 | 2.358E-03 | 2.608E-03 | 2.214E-03 |
| 135.0 | 2.014E-03 | 2.324E-03 | 2.352E-03 | 2.365E-03 | 2.470E-03 |
| 137.5 | 2.650E-03 | 3.401E-03 | 3.556E-03 | 3.834E-03 | 2.980E-03 |
| 140.0 | 2.181E-03 | 2.526E-03 | 2.740E-03 | 3.330E-03 | 2.947E-03 |
| 142.5 | 2.385E-03 | 2.716E-03 | 2.733E-03 | 2.903E-03 | 3.109E-03 |
| 145.0 | 2.759E-03 | 2.611E-03 | 2.664E-03 | 2.962E-03 | 2.663E-03 |
| 147.5 | 3.093E-03 | 3.383E-03 | 3.359E-03 | 3.489E-03 | 4.557E-03 |
| 150.0 | 2.978E-03 | 4.269E-03 | 4.720E-03 | 6.018E-03 | 5.698E-03 |
| 152.5 | 5.358E-03 | 6.927E-03 | 7.562E-03 | 9.384E-03 | 1.006E-02 |
| 155.0 | 1.247E-02 | 1.654E-02 | 1.792E-02 | 2.108E-02 | 2.083E-02 |
| 156.0 | 2.342E-02 | 2.520E-02 | 2.544E-02 | 2.585E-02 | 2.659E-02 |
| 157.0 | 3.631E-02 | 3.347E-02 | 3.270E-02 | 3.064E-02 | 3.289E-02 |
| 158.0 | 5.553E-02 | 4.793E-02 | 4.589E-02 | 4.143E-02 | 4.194E-02 |
| 159.0 | 6.819E-02 | 5.652E-02 | 5.526E-02 | 5.379E-02 | 5.059E-02 |
| 160.0 | 7.871E-02 | 7.031E-02 | 6.784E-02 | 6.267E-02 | 5.701E-02 |
| 161.0 | 6.399E-02 | 6.646E-02 | 6.489E-02 | 5.920E-02 | 6.397E-02 |
| 162.0 | 4.753E-02 | 5.884E-02 | 5.948E-02 | 5.842E-02 | 6.281E-02 |
| 163.0 | 4.195E-02 | 5.713E-02 | 6.025E-02 | 6.491E-02 | 5.877E-02 |
| 164.0 | 3.674E-02 | 4.225E-02 | 4.639E-02 | 5.729E-02 | 5.625E-02 |
| 165.0 | 3.931E-02 | 4.073E-02 | 4.246E-02 | 4.847E-02 | 5.092E-02 |
| 166.0 | 4.204E-02 | 3.774E-02 | 3.735E-02 | 3.984E-02 | 4.340E-02 |
| 167.0 | 4.576E-02 | 4.305E-02 | 4.171E-02 | 4.145E-02 | 4.241E-02 |
| 168.0 | 4.541E-02 | 4.660E-02 | 4.646E-02 | 4.741E-02 | 4.638E-02 |
| 169.0 | 4.510E-02 | 4.720E-02 | 4.762E-02 | 4.793E-02 | 4.787E-02 |
| 170.0 | 5.030E-02 | 5.274E-02 | 5.222E-02 | 5.001E-02 | 4.865E-02 |
| 171.0 | 4.541E-02 | 4.964E-02 | 5.174E-02 | 5.575E-02 | 5.444E-02 |
| 172.0 | 5.182E-02 | 5.812E-02 | 5.968E-02 | 6.241E-02 | 6.254E-02 |
| 173.0 | 6.087E-02 | 6.307E-02 | 6.392E-02 | 6.710E-02 | 6.857E-02 |
| 174.0 | 6.524E-02 | 6.933E-02 | 7.116E-02 | 7.907E-02 | 7.905E-02 |
| 175.0 | 8.189E-02 | 8.663E-02 | 8.947E-02 | 1.049E-01 | 1.030E-01 |
| 176.0 | 8.688E-02 | 1.052E-01 | 1.146E-01 | 1.457E-01 | 1.452E-01 |
| 177.0 | 1.188E-01 | 1.553E-01 | 1.690E-01 | 1.875E-01 | 1.766E-01 |
| 178.0 | 2.064E-01 | 2.410E-01 | 2.272E-01 | 1.585E-01 | 1.302E-01 |
| 179.0 | 3.006E-01 | 1.195E-01 | 9.060E-02 | 4.782E-02 | 3.917E-02 |
| 180.0 | 6.750E-02 | 4.717E-02 | 4.434E-02 | 3.769E-02 | 3.369E-02 |

TABLE III-C. NORMALIZED VOLUME SCATTERING FUNCTION: HAZE M MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 2.266E 01 | 1.012E 01 | 8.494E 00 | 5.850E 00 | 5.135E 00 |
| 1.0 | 1.978E 01 | 9.524E 00 | 8.084E 00 | 5.680E 00 | 5.010E 00 |
| 2.0 | 1.428E 01 | 8.080E 00 | 7.063E 00 | 5.228E 00 | 4.670E 00 |
| 3.0 | 9.728E 00 | 6.467E 00 | 5.851E 00 | 4.625E 00 | 4.204E 00 |
| 4.0 | 6.645E 00 | 5.094E 00 | 4.753E 00 | 3.997E 00 | 3.704E 00 |
| 5.0 | 4.646E 00 | 4.037E 00 | 3.862E 00 | 3.419E 00 | 3.230E 00 |
| 6.0 | 3.351E 00 | 3.242E 00 | 3.163E 00 | 2.918E 00 | 2.809E 00 |
| 7.0 | 2.500E 00 | 2.643E 00 | 2.618E 00 | 2.495E 00 | 2.444E 00 |
| 8.0 | 1.928E 00 | 2.184E 00 | 2.190E 00 | 2.144E 00 | 2.130E 00 |
| 9.0 | 1.536E 00 | 1.824E 00 | 1.849E 00 | 1.855E 00 | 1.862E 00 |
| 10.0 | 1.264E 00 | 1.538E 00 | 1.573E 00 | 1.618E 00 | 1.634E 00 |
| 11.0 | 1.070E 00 | 1.308E 00 | 1.348E 00 | 1.421E 00 | 1.439E 00 |
| 12.0 | 9.301E-01 | 1.125E 00 | 1.167E 00 | 1.258E 00 | 1.274E 00 |
| 13.0 | 8.250E-01 | 9.799E-01 | 1.022E 00 | 1.121E 00 | 1.134E 00 |
| 14.0 | 7.424E-01 | 8.671E-01 | 9.060E-01 | 1.005E 00 | 1.016E 00 |
| 15.0 | 6.742E-01 | 7.786E-01 | 8.129E-01 | 9.040E-01 | 9.143E-01 |
| 16.0 | 6.155E-01 | 7.065E-01 | 7.360E-01 | 8.153E-01 | 8.266E-01 |
| 17.0 | 5.620E-01 | 6.446E-01 | 6.695E-01 | 7.357E-01 | 7.498E-01 |
| 18.0 | 5.080E-01 | 5.881E-01 | 6.096E-01 | 6.636E-01 | 6.814E-01 |
| 19.0 | 4.501E-01 | 5.346E-01 | 5.540E-01 | 5.986E-01 | 6.199E-01 |
| 20.0 | 3.946E-01 | 4.834E-01 | 5.020E-01 | 5.413E-01 | 5.643E-01 |
| 22.5 | 3.197E-01 | 3.853E-01 | 4.015E-01 | 4.347E-01 | 4.522E-01 |
| 25.0 | 3.229E-01 | 3.352E-01 | 3.416E-01 | 3.575E-01 | 3.691E-01 |
| 27.5 | 2.126E-01 | 2.594E-01 | 2.680E-01 | 2.844E-01 | 2.956E-01 |
| 30.0 | 2.005E-01 | 2.174E-01 | 2.225E-01 | 2.372E-01 | 2.409E-01 |
| 32.5 | 1.841E-01 | 1.854E-01 | 1.882E-01 | 1.998E-01 | 1.991E-01 |
| 35.0 | 1.389E-01 | 1.520E-01 | 1.546E-01 | 1.619E-01 | 1.639E-01 |
| 37.5 | 1.198E-01 | 1.295E-01 | 1.310E-01 | 1.347E-01 | 1.367E-01 |
| 40.0 | 1.095E-01 | 1.097E-01 | 1.107E-01 | 1.146E-01 | 1.145E-01 |
| 42.5 | 8.921E-02 | 9.189E-02 | 9.282E-02 | 9.517E-02 | 9.599E-02 |
| 45.0 | 7.162E-02 | 7.916E-02 | 7.950E-02 | 7.972E-02 | 8.114E-02 |
| 47.5 | 6.834E-02 | 6.641E-02 | 6.696E-02 | 6.901E-02 | 6.863E-02 |
| 50.0 | 5.563E-02 | 5.788E-02 | 5.804E-02 | 5.832E-02 | 5.870E-02 |
| 52.5 | 4.560E-02 | 4.899E-02 | 4.922E-02 | 4.926E-02 | 4.994E-02 |
| 55.0 | 4.109E-02 | 4.181E-02 | 4.209E-02 | 4.281E-02 | 4.279E-02 |
| 57.5 | 3.615E-02 | 3.708E-02 | 3.709E-02 | 3.697E-02 | 3.713E-02 |
| 60.0 | 2.840E-02 | 3.115E-02 | 3.137E-02 | 3.141E-02 | 3.189E-02 |
| 62.5 | 2.562E-02 | 2.722E-02 | 2.748E-02 | 2.789E-02 | 2.797E-02 |
| 65.0 | 2.461E-02 | 2.511E-02 | 2.507E-02 | 2.480E-02 | 2.491E-02 |
| 67.5 | 1.792E-02 | 2.086E-02 | 2.108E-02 | 2.107E-02 | 2.152E-02 |
| 70.0 | 1.719E-02 | 1.834E-02 | 1.851E-02 | 1.877E-02 | 1.889E-02 |
| 72.5 | 1.557E-02 | 1.670E-02 | 1.682E-02 | 1.685E-02 | 1.699E-02 |
| 75.0 | 1.254E-02 | 1.480E-02 | 1.495E-02 | 1.481E-02 | 1.520E-02 |
| 77.5 | 1.179E-02 | 1.313E-02 | 1.328E-02 | 1.342E-02 | 1.359E-02 |
| 80.0 | 1.072E-02 | 1.187E-02 | 1.202E-02 | 1.213E-02 | 1.230E-02 |
| 82.5 | 9.072E-03 | 1.076E-02 | 1.091E-02 | 1.092E-02 | 1.121E-02 |
| 85.0 | 8.484E-03 | 9.937E-03 | 1.005E-02 | 1.004E-02 | 1.028E-02 |
| 87.5 | 7.697E-03 | 8.904E-03 | 9.066E-03 | 9.229E-03 | 9.395E-03 |
| 90.0 | 7.335E-03 | 8.385E-03 | 8.518E-03 | 8.609E-03 | 8.772E-03 |
| 92.5 | 6.240E-03 | 7.887E-03 | 8.010E-03 | 7.920E-03 | 8.224E-03 |

TABLE III-C. NORMALIZED VOLUME SCATTERING FUNCTION: HAZE M MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 6.075E-03 | 7.268E-03 | 7.404E-03 | 7.492E-03 | 7.670E-03 |
| 97.5 | 6.267E-03 | 6.954E-03 | 7.077E-03 | 7.246E-03 | 7.296E-03 |
| 100.0 | 5.266E-03 | 6.675E-03 | 6.788E-03 | 6.732E-03 | 6.976E-03 |
| 102.5 | 5.200E-03 | 6.342E-03 | 6.459E-03 | 6.511E-03 | 6.666E-03 |
| 105.0 | 5.679E-03 | 6.165E-03 | 6.285E-03 | 6.452E-03 | 6.481E-03 |
| 107.5 | 4.918E-03 | 6.221E-03 | 6.301E-03 | 6.170E-03 | 6.391E-03 |
| 110.0 | 4.970E-03 | 5.905E-03 | 6.019E-03 | 6.056E-03 | 6.192E-03 |
| 112.5 | 5.381E-03 | 5.899E-03 | 5.999E-03 | 6.112E-03 | 6.137E-03 |
| 115.0 | 5.249E-03 | 6.097E-03 | 6.170E-03 | 6.111E-03 | 6.218E-03 |
| 117.5 | 5.189E-03 | 6.215E-03 | 6.281E-03 | 6.177E-03 | 6.292E-03 |
| 120.0 | 6.145E-03 | 6.488E-03 | 6.516E-03 | 6.439E-03 | 6.424E-03 |
| 122.5 | 5.815E-03 | 6.579E-03 | 6.629E-03 | 6.529E-03 | 6.556E-03 |
| 125.0 | 6.621E-03 | 7.259E-03 | 7.213E-03 | 6.857E-03 | 6.891E-03 |
| 127.5 | 7.506E-03 | 7.638E-03 | 7.600E-03 | 7.332E-03 | 7.226E-03 |
| 130.0 | 8.067E-03 | 8.417E-03 | 8.296E-03 | 7.701E-03 | 7.687E-03 |
| 132.5 | 9.300E-03 | 9.236E-03 | 9.015E-03 | 8.298E-03 | 8.159E-03 |
| 135.0 | 1.180E-02 | 9.833E-03 | 9.598E-03 | 9.108E-03 | 8.660E-03 |
| 137.5 | 1.151E-02 | 1.124E-02 | 1.084E-02 | 9.564E-03 | 9.462E-03 |
| 140.0 | 1.336E-02 | 1.231E-02 | 1.186E-02 | 1.043E-02 | 1.024E-02 |
| 142.5 | 1.556E-02 | 1.381E-02 | 1.316E-02 | 1.135E-02 | 1.104E-02 |
| 145.0 | 1.675E-02 | 1.481E-02 | 1.403E-02 | 1.196E-02 | 1.161E-02 |
| 147.5 | 1.522E-02 | 1.428E-02 | 1.375E-02 | 1.236E-02 | 1.176E-02 |
| 150.0 | 1.600E-02 | 1.477E-02 | 1.422E-02 | 1.292E-02 | 1.219E-02 |
| 152.5 | 1.550E-02 | 1.507E-02 | 1.461E-02 | 1.328E-02 | 1.271E-02 |
| 155.0 | 1.560E-02 | 1.545E-02 | 1.500E-02 | 1.368E-02 | 1.316E-02 |
| 156.0 | 1.509E-02 | 1.534E-02 | 1.496E-02 | 1.384E-02 | 1.326E-02 |
| 157.0 | 1.521E-02 | 1.529E-02 | 1.495E-02 | 1.411E-02 | 1.337E-02 |
| 158.0 | 1.622E-02 | 1.542E-02 | 1.509E-02 | 1.454E-02 | 1.354E-02 |
| 159.0 | 1.750E-02 | 1.572E-02 | 1.538E-02 | 1.506E-02 | 1.378E-02 |
| 160.0 | 1.824E-02 | 1.616E-02 | 1.579E-02 | 1.551E-02 | 1.411E-02 |
| 161.0 | 1.811E-02 | 1.671E-02 | 1.632E-02 | 1.583E-02 | 1.448E-02 |
| 162.0 | 1.753E-02 | 1.730E-02 | 1.687E-02 | 1.603E-02 | 1.488E-02 |
| 163.0 | 1.725E-02 | 1.785E-02 | 1.741E-02 | 1.623E-02 | 1.527E-02 |
| 164.0 | 1.753E-02 | 1.846E-02 | 1.801E-02 | 1.652E-02 | 1.567E-02 |
| 165.0 | 1.833E-02 | 1.931E-02 | 1.877E-02 | 1.693E-02 | 1.609E-02 |
| 166.0 | 1.974E-02 | 2.039E-02 | 1.968E-02 | 1.743E-02 | 1.650E-02 |
| 167.0 | 2.168E-02 | 2.151E-02 | 2.061E-02 | 1.786E-02 | 1.681E-02 |
| 168.0 | 2.366E-02 | 2.248E-02 | 2.136E-02 | 1.807E-02 | 1.694E-02 |
| 169.0 | 2.505E-02 | 2.313E-02 | 2.178E-02 | 1.786E-02 | 1.680E-02 |
| 170.0 | 2.535E-02 | 2.326E-02 | 2.171E-02 | 1.715E-02 | 1.631E-02 |
| 171.0 | 2.456E-02 | 2.273E-02 | 2.104E-02 | 1.604E-02 | 1.550E-02 |
| 172.0 | 2.334E-02 | 2.152E-02 | 1.981E-02 | 1.476E-02 | 1.447E-02 |
| 173.0 | 2.240E-02 | 1.998E-02 | 1.835E-02 | 1.364E-02 | 1.345E-02 |
| 174.0 | 2.190E-02 | 1.869E-02 | 1.717E-02 | 1.296E-02 | 1.279E-02 |
| 175.0 | 2.167E-02 | 1.821E-02 | 1.681E-02 | 1.293E-02 | 1.277E-02 |
| 176.0 | 2.168E-02 | 1.896E-02 | 1.761E-02 | 1.360E-02 | 1.356E-02 |
| 177.0 | 2.208E-02 | 2.104E-02 | 1.962E-02 | 1.490E-02 | 1.507E-02 |
| 178.0 | 2.329E-02 | 2.410E-02 | 2.245E-02 | 1.652E-02 | 1.693E-02 |
| 179.0 | 2.545E-02 | 2.713E-02 | 2.515E-02 | 1.793E-02 | 1.850E-02 |
| 180.0 | 2.694E-02 | 2.848E-02 | 2.629E-02 | 1.849E-02 | 1.912E-02 |

TABLE III-D. NORMALIZED VOLUME SCATTERING FUNCTION: HAZE M MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 2.201E 01 | 1.010E 01 | 8.304E 00 | 5.112E 00 | 4.542E 00 |
| 1.0 | 1.910E 01 | 9.497E 00 | 7.891E 00 | 4.955E 00 | 4.424E 00 |
| 2.0 | 1.360E 01 | [illegible].030E 00 | 6.860E 00 | 4.536E 00 | 4.103E 00 |
| 3.0 | 9.157E 00 | 6.374E 00 | 5.629E 00 | 3.980E 00 | 3.662E 00 |
| 4.0 | 6.201E 00 | 4.943E 00 | 4.499E 00 | 3.405E 00 | 3.187E 00 |
| 5.0 | 4.298E 00 | 3.816E 00 | 3.568E 00 | 2.878E 00 | 2.736E 00 |
| 6.0 | 3.049E 00 | 2.953E 00 | 2.830E 00 | 2.425E 00 | 2.336E 00 |
| 7.0 | 2.209E 00 | 2.303E 00 | 2.257E 00 | 2.048E 00 | 1.995E 00 |
| 8.0 | 1.646E 00 | 1.822E 00 | 1.822E 00 | 1.741E 00 | 1.710E 00 |
| 9.0 | 1.286E 00 | 1.473E 00 | 1.497E 00 | 1.496E 00 | 1.476E 00 |
| 10.0 | 1.063E 00 | 1.225E 00 | 1.257E 00 | 1.300E 00 | 1.286E 00 |
| 11.0 | 9.329E-01 | 1.047E 00 | 1.080E 00 | 1.139E 00 | 1.130E 00 |
| 12.0 | 8.515E-01 | 9.145E-01 | 9.424E-01 | 1.005E 00 | 1.000E 00 |
| 13.0 | 7.586E-01 | 8.040E-01 | 8.285E-01 | 8.888E-01 | 8.899E-01 |
| 14.0 | 6.317E-01 | 7.035E-01 | 7.281E-01 | 7.873E-01 | 7.950E-01 |
| 15.0 | 5.055E-01 | 6.132E-01 | 6.396E-01 | 6.996E-01 | 7.127E-01 |
| 16.0 | 4.162E-01 | 5.381E-01 | 5.651E-01 | 6.261E-01 | 6.416E-01 |
| 17.0 | 3.689E-01 | 4.803E-01 | 5.059E-01 | 5.662E-01 | 5.811E-01 |
| 18.0 | 3.493E-01 | 4.380E-01 | 4.605E-01 | 5.176E-01 | 5.300E-01 |
| 19.0 | 3.399E-01 | 4.066E-01 | 4.253E-01 | 4.774E-01 | 4.866E-01 |
| 20.0 | 3.316E-01 | 3.808E-01 | 3.958E-01 | 4.429E-01 | 4.490E-01 |
| 22.5 | 2.942E-01 | 3.182E-01 | 3.291E-01 | 3.702E-01 | 3.702E-01 |
| 25.0 | 2.402E-01 | 2.624E-01 | 2.721E-01 | 3.082E-01 | 3.085E-01 |
| 27.5 | 2.016E-01 | 2.262E-01 | 2.338E-01 | 2.594E-01 | 2.630E-01 |
| 30.0 | 1.934E-01 | 2.021E-01 | 2.075E-01 | 2.251E-01 | 2.292E-01 |
| 32.5 | 1.753E-01 | 1.775E-01 | 1.824E-01 | 1.943E-01 | 2.006E-01 |
| 35.0 | 1.365E-01 | 1.557E-01 | 1.599E-01 | 1.642E-01 | 1.754E-01 |
| 37.5 | 1.251E-01 | 1.368E-01 | 1.403E-01 | 1.445E-01 | 1.533E-01 |
| 40.0 | 1.219E-01 | 1.205E-01 | 1.236E-01 | 1.297E-01 | 1.343E-01 |
| 42.5 | 9.803E-02 | 1.075E-01 | 1.097E-01 | 1.128E-01 | 1.179E-01 |
| 45.0 | 8.656E-02 | 9.422E-02 | 9.620E-02 | 1.001E-01 | 1.033E-01 |
| 47.5 | 8.451E-02 | 8.375E-02 | 8.542E-02 | 9.073E-02 | 9.113E-02 |
| 50.0 | 7.268E-02 | 7.668E-02 | 7.756E-02 | 8.007E-02 | 8.110E-02 |
| 52.5 | 6.118E-02 | 6.681E-02 | 6.794E-02 | 7.048E-02 | 7.166E-02 |
| 55.0 | 5.725E-02 | 5.[illegible]86E-02 | 6.095E-02 | 6.397E-02 | 6.408E-02 |
| 57.5 | 5.523E-02 | 5.591E-02 | 5.626E-02 | 5.739E-02 | 5.774E-02 |
| 60.0 | 4.211E-02 | 4.784E-02 | 4.874E-02 | 5.021E-02 | 5.114E-02 |
| 62.5 | 4.166E-02 | 4.426E-02 | 4.472E-02 | 4.577E-02 | 4.613E-02 |
| 65.0 | 3.776E-02 | 3.930E-02 | 3.989E-02 | 4.156E-02 | 4.144E-02 |
| 67.5 | 3.339E-02 | 3.596E-02 | 3.646E-02 | 3.757E-02 | 3.766E-02 |
| 70.0 | 2.906E-02 | 3.288E-02 | 3.328E-02 | 3.371E-02 | 3.421E-02 |
| 72.5 | 2.655E-02 | 2.878E-02 | 2.936E-02 | 3.055E-02 | 3.075E-02 |
| 75.0 | 2.539E-02 | 2.704E-02 | 2.740E-02 | 2.813E-02 | 2.825E-02 |
| 77.5 | 2.088E-02 | 2.426E-02 | 2.470E-02 | 2.529E-02 | 2.573E-02 |
| 80.0 | 1.963E-02 | 2.190E-02 | 2.240E-02 | 2.329E-02 | 2.359E-02 |
| 82.5 | 1.905E-02 | 2.075E-02 | 2.117E-02 | 2.201E-02 | 2.210E-02 |
| 85.0 | 1.697E-02 | 1.939E-02 | 1.976E-02 | 2.021E-02 | 2.047E-02 |
| 87.5 | 1.506E-02 | 1.707E-02 | 1.742E-02 | 1.800E-02 | 1.823E-02 |
| 90.0 | 1.327E-02 | 1.461E-02 | 1.501E-02 | 1.599E-02 | 1.604E-02 |
| 92.5 | 1.150E-02 | 1.342E-02 | 1.378E-02 | 1.449E-02 | 1.480E-02 |

TABLE III-D. NORMALIZED VOLUME SCATTERING FUNCTION: HAZE M MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.083E-02 | 1.294E-02 | 1.337E-02 | 1.420E-02 | 1.441E-02 |
| 97.5 | 1.137E-02 | 1.317E-02 | 1.353E-02 | 1.417E-02 | 1.431E-02 |
| 100.0 | 1.018E-02 | 1.236E-02 | 1.278E-02 | 1.349E-02 | 1.367E-02 |
| 102.5 | 9.645E-03 | 1.158E-02 | 1.196E-02 | 1.265E-02 | 1.279E-02 |
| 105.0 | 9.216E-03 | 1.069E-02 | 1.101E-02 | 1.165E-02 | 1.176E-02 |
| 107.5 | 7.837E-03 | 9.176E-03 | 9.576E-03 | 1.049E-02 | 1.061E-02 |
| 110.0 | 7.075E-03 | 8.521E-03 | 8.889E-03 | 9.707E-03 | 9.912E-03 |
| 112.5 | 7.474E-03 | 8.473E-03 | 8.798E-03 | 9.593E-03 | 9.704E-03 |
| 115.0 | 7.344E-03 | 8.375E-03 | 8.741E-03 | 9.612E-03 | 9.707E-03 |
| 117.5 | 6.591E-03 | 8.395E-03 | 8.808E-03 | 9.575E-03 | 9.861E-03 |
| 120.0 | 6.770E-03 | 8.531E-03 | 8.970E-03 | 9.821E-03 | 1.007E-02 |
| 122.5 | 6.762E-03 | 8.543E-03 | 9.001E-03 | 1.000E-02 | 1.016E-02 |
| 125.0 | 6.194E-03 | 8.479E-03 | 8.952E-03 | 1.000E-02 | 1.018E-02 |
| 127.5 | 6.604E-03 | 8.478E-03 | 8.946E-03 | 1.023E-02 | 1.020E-02 |
| 130.0 | 6.721E-03 | 8.407E-03 | 8.913E-03 | 1.050E-02 | 1.029E-02 |
| 132.5 | 7.062E-03 | 8.737E-03 | 9.258E-03 | 1.088E-02 | 1.067E-02 |
| 135.0 | 7.519E-03 | 9.434E-03 | 9.970E-03 | 1.133E-02 | 1.139E-02 |
| 137.5 | 7.602E-03 | 1.023E-02 | 1.083E-02 | 1.185E-02 | 1.235E-02 |
| 140.0 | 9.132E-03 | 1.146E-02 | 1.208E-02 | 1.306E-02 | 1.358E-02 |
| 142.5 | 1.036E-02 | 1.283E-02 | 1.347E-02 | 1.459E-02 | 1.496E-02 |
| 145.0 | 1.076E-02 | 1.410E-02 | 1.483E-02 | 1.633E-02 | 1.644E-02 |
| 147.5 | 1.363E-02 | 1.661E-02 | 1.727E-02 | 1.909E-02 | 1.860E-02 |
| 150.0 | 1.745E-02 | 2.024E-02 | 2.078E-02 | 2.237E-02 | 2.155E-02 |
| 152.5 | 2.114E-02 | 2.429E-02 | 2.476E-02 | 2.583E-02 | 2.498E-02 |
| 155.0 | 2.956E-02 | 3.030E-02 | 3.035E-02 | 3.053E-02 | 2.919E-02 |
| 156.0 | 3.272E-02 | 3.291E-02 | 3.276E-02 | 3.254E-02 | 3.095E-02 |
| 157.0 | 3.560E-02 | 3.539E-02 | 3.507E-02 | 3.445E-02 | 3.263E-02 |
| 158.0 | 3.904E-02 | 3.780E-02 | 3.730E-02 | 3.620E-02 | 3.422E-02 |
| 159.0 | 4.254E-02 | 4.028E-02 | 3.954E-02 | 3.775E-02 | 3.572E-02 |
| 160.0 | 4.484E-02 | 4.287E-02 | 4.182E-02 | 3.906E-02 | 3.711E-02 |
| 161.0 | 4.621E-02 | 4.534E-02 | 4.398E-02 | 4.025E-02 | 3.834E-02 |
| 162.0 | 4.904E-02 | 4.740E-02 | 4.581E-02 | 4.146E-02 | 3.939E-02 |
| 163.0 | 5.347E-02 | 4.900E-02 | 4.726E-02 | 4.270E-02 | 4.021E-02 |
| 164.0 | 5.646E-02 | 5.033E-02 | 4.845E-02 | 4.380E-02 | 4.085E-02 |
| 165.0 | 5.718E-02 | 5.152E-02 | 4.950E-02 | 4.464E-02 | 4.135E-02 |
| 166.0 | 5.743E-02 | 5.271E-02 | 5.053E-02 | 4.532E-02 | 4.181E-02 |
| 167.0 | 5.946E-02 | 5.403E-02 | 5.162E-02 | 4.602E-02 | 4.226E-02 |
| 168.0 | 6.252E-02 | 5.528E-02 | 5.262E-02 | 4.675E-02 | 4.268E-02 |
| 169.0 | 6.457E-02 | 5.604E-02 | 5.327E-02 | 4.737E-02 | 4.306E-02 |
| 170.0 | 6.588E-02 | 5.656E-02 | 5.376E-02 | 4.783E-02 | 4.349E-02 |
| 171.0 | 6.749E-02 | 5.737E-02 | 5.439E-02 | 4.821E-02 | 4.407E-02 |
| 172.0 | 6.933E-02 | 5.848E-02 | 5.528E-02 | 4.863E-02 | 4.488E-02 |
| 173.0 | 7.146E-02 | 5.962E-02 | 5.623E-02 | 4.926E-02 | 4.596E-02 |
| 174.0 | 7.417E-02 | 6.037E-02 | 5.697E-02 | 5.027E-02 | 4.736E-02 |
| 175.0 | 7.614E-02 | 6.049E-02 | 5.746E-02 | 5.177E-02 | 4.910E-02 |
| 176.0 | 7.499E-02 | 6.014E-02 | 5.785E-02 | 5.372E-02 | 5.119E-02 |
| 177.0 | 6.914E-02 | 5.961E-02 | 5.841E-02 | 5.612E-02 | 5.369E-02 |
| 178.0 | 6.148E-02 | 6.000E-02 | 5.990E-02 | 5.890E-02 | 5.643E-02 |
| 179.0 | 5.836E-02 | 6.216E-02 | 6.237E-02 | 6.143E-02 | 5.875E-02 |
| 180.0 | 6.025E-02 | 6.365E-02 | 6.373E-02 | 6.249E-02 | 5.969E-02 |

TABLE III-E. NORMALIZED VOLUME SCATTERING FUNCTION: HAZE C MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 1.006E 01 | 6.468E 00 | 5.936E 00 | 5.664E 00 | 5.226E 00 |
| 1.0 | 7.819E 00 | 5.706E 00 | 5.320E 00 | 5.227E 00 | 4.884E 00 |
| 2.0 | 4.893E 00 | 4.219E 00 | 4.053E 00 | 4.231E 00 | 4.070E 00 |
| 3.0 | 3.551E 00 | 3.123E 00 | 3.030E 00 | 3.254E 00 | 3.209E 00 |
| 4.0 | 2.816E 00 | 2.536E 00 | 2.452E 00 | 2.586E 00 | 2.567E 00 |
| 5.0 | 2.350E 00 | 2.161E 00 | 2.097E 00 | 2.167E 00 | 2.150E 00 |
| 6.0 | 2.018E 00 | 1.888E 00 | 1.834E 00 | 1.872E 00 | 1.860E 00 |
| 7.0 | 1.777E 00 | 1.681E 00 | 1.633E 00 | 1.648E 00 | 1.637E 00 |
| 8.0 | 1.586E 00 | 1.511E 00 | 1.469E 00 | 1.474E 00 | 1.461E 00 |
| 9.0 | 1.428E 00 | 1.367E 00 | 1.330E 00 | 1.331E 00 | 1.321E 00 |
| 10.0 | 1.299E 00 | 1.242E 00 | 1.210E 00 | 1.211E 00 | 1.204E 00 |
| 11.0 | 1.188E 00 | 1.133E 00 | 1.104E 00 | 1.111E 00 | 1.103E 00 |
| 12.0 | 1.092E 00 | 1.038E 00 | 1.011E 00 | 1.023E 00 | 1.015E 00 |
| 13.0 | 1.007E 00 | 9.538E-01 | 9.305E-01 | 9.448E-01 | 9.376E-01 |
| 14.0 | 9.306E-01 | 8.810E-01 | 8.605E-01 | 8.739E-01 | 8.685E-01 |
| 15.0 | 8.612E-01 | 8.174E-01 | 7.983E-01 | 8.101E-01 | 8.059E-01 |
| 16.0 | 7.972E-01 | 7.599E-01 | 7.427E-01 | 7.520E-01 | 7.476E-01 |
| 17.0 | 7.380E-01 | 7.072E-01 | 6.923E-01 | 6.977E-01 | 6.929E-01 |
| 18.0 | 6.829E-01 | 6.585E-01 | 6.449E-01 | 6.459E-01 | 6.419E-01 |
| 19.0 | 6.298E-01 | 6.120E-01 | 5.994E-01 | 5.975E-01 | 5.947E-01 |
| 20.0 | 5.809E-01 | 5.675E-01 | 5.568E-01 | 5.531E-01 | 5.501E-01 |
| 22.5 | 4.804E-01 | 4.694E-01 | 4.614E-01 | 4.592E-01 | 4.571E-01 |
| 25.0 | 4.134E-01 | 4.056E-01 | 3.994E-01 | 3.965E-01 | 3.942E-01 |
| 27.5 | 3.324E-01 | 3.313E-01 | 3.274E-01 | 3.225E-01 | 3.212E-01 |
| 30.0 | 2.824E-01 | 2.811E-01 | 2.788E-01 | 2.771E-01 | 2.763E-01 |
| 32.5 | 2.396E-01 | 2.384E-01 | 2.373E-01 | 2.372E-01 | 2.363E-01 |
| 35.0 | 1.982E-01 | 2.009E-01 | 2.008E-01 | 1.983E-01 | 1.979E-01 |
| 37.5 | 1.673E-01 | 1.714E-01 | 1.720E-01 | 1.691E-01 | 1.690E-01 |
| 40.0 | 1.424E-01 | 1.463E-01 | 1.473E-01 | 1.458E-01 | 1.457E-01 |
| 42.5 | 1.196E-01 | 1.247E-01 | 1.261E-01 | 1.243E-01 | 1.243E-01 |
| 45.0 | 1.004E-01 | 1.077E-01 | 1.094E-01 | 1.059E-01 | 1.062E-01 |
| 47.5 | 8.672E-02 | 9.201E-02 | 9.398E-02 | 9.266E-02 | 9.294E-02 |
| 50.0 | 7.334E-02 | 7.983E-02 | 8.193E-02 | 7.962E-02 | 7.996E-02 |
| 52.5 | 6.226E-02 | 6.892E-02 | 7.113E-02 | 6.873E-02 | 6.918E-02 |
| 55.0 | 5.364E-02 | 5.968E-02 | 6.193E-02 | 6.016E-02 | 6.060E-02 |
| 57.5 | 4.621E-02 | 5.233E-02 | 5.456E-02 | 5.270E-02 | 5.316E-02 |
| 60.0 | 3.936E-02 | 4.547E-02 | 4.767E-02 | 4.576E-02 | 4.627E-02 |
| 62.5 | 3.428E-02 | 3.983E-02 | 4.197E-02 | 4.043E-02 | 4.095E-02 |
| 65.0 | 3.032E-02 | 3.566E-02 | 3.771E-02 | 3.622E-02 | 3.670E-02 |
| 67.5 | 2.571E-02 | 3.104E-02 | 3.302E-02 | 3.145E-02 | 3.195E-02 |
| 70.0 | 2.277E-02 | 2.755E-02 | 2.946E-02 | 2.824E-02 | 2.875E-02 |
| 72.5 | 2.013E-02 | 2.462E-02 | 2.643E-02 | 2.535E-02 | 2.585E-02 |
| 75.0 | 1.758E-02 | 2.198E-02 | 2.371E-02 | 2.256E-02 | 2.304E-02 |
| 77.5 | 1.575E-02 | 1.970E-02 | 2.135E-02 | 2.046E-02 | 2.094E-02 |
| 80.0 | 1.410E-02 | 1.777E-02 | 1.933E-02 | 1.857E-02 | 1.905E-02 |
| 82.5 | 1.258E-02 | 1.608E-02 | 1.756E-02 | 1.682E-02 | 1.729E-02 |
| 85.0 | 1.142E-02 | 1.468E-02 | 1.608E-02 | 1.545E-02 | 1.591E-02 |
| 87.5 | 1.038E-02 | 1.335E-02 | 1.469E-02 | 1.422E-02 | 1.468E-02 |
| 90.0 | 9.557E-03 | 1.231E-02 | 1.358E-02 | 1.321E-02 | 1.366E-02 |
| 92.5 | 8.704E-03 | 1.138E-02 | 1.259E-02 | 1.220E-02 | 1.265E-02 |

TABLE III-E. NORMALIZED VOLUME SCATTERING FUNCTION : HAZE C MODEL
INDEX OF REFRACTION = 1.33

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 8.139E-03 | 1.055E-02 | 1.172E-02 | 1.148E-02 | 1.193E-02 |
| 97.5 | 7.710E-03 | 9.875E-03 | 1.099E-02 | 1.092E-02 | 1.136E-02 |
| 100.0 | 7.141E-03 | 9.304E-03 | 1.037E-02 | 1.024E-02 | 1.069E-02 |
| 102.5 | [illegible] | 8.786E-03 | 9.817E-03 | 9.796E-03 | 1.025E-02 |
| 105.0 | 6.622E-03 | 8.366E-03 | 9.363E-03 | 9.520E-03 | 9.974E-03 |
| 107.5 | 6.269E-03 | 8.078E-03 | 9.043E-03 | 9.107E-03 | 9.565E-03 |
| 110.0 | 6.112E-03 | 7.722E-03 | 8.663E-03 | 8.885E-03 | 9.343E-03 |
| 112.5 | 6.070E-03 | 7.518E-03 | 8.435E-03 | 8.776E-03 | 9.239E-03 |
| 115.0 | 5.978E-03 | 7.412E-03 | 8.305E-03 | 8.640E-03 | 9.109E-03 |
| 117.5 | 5.928E-03 | 7.325E-03 | 8.196E-03 | 8.547E-03 | 9.027E-03 |
| 120.0 | 6.095E-03 | 7.301E-03 | [illegible] | 8.666E-03 | 9.150E-03 |
| 122.5 | 6.073E-03 | 7.251E-03 | 8.093E-03 | 8.615E-03 | 9.111E-03 |
| 125.0 | 6.288E-03 | 7.427E-03 | 8.248E-03 | 8.809E-03 | 9.304E-03 |
| 127.5 | 6.552E-03 | 7.506E-03 | 8.310E-03 | 9.051E-03 | 9.544E-03 |
| 130.0 | 6.816E-03 | 7.772E-03 | 8.562E-03 | 9.273E-03 | 9.787E-03 |
| 132.5 | 7.219E-03 | 8.116E-03 | 8.889E-03 | 9.634E-03 | 1.016E-02 |
| 135.0 | 7.978E-03 | 8.365E-03 | 9.120E-03 | 1.028E-02 | 1.079E-02 |
| 137.5 | 8.254E-03 | 8.967E-03 | 9.703E-03 | 1.049E-02 | 1.099E-02 |
| 140.0 | 8.927E-03 | 9.382E-03 | 1.008E-02 | 1.103E-02 | 1.155E-02 |
| 142.5 | 9.609E-03 | 9.998E-03 | 1.068E-02 | 1.171E-02 | 1.222E-02 |
| 145.0 | 1.015E-02 | 1.051E-02 | 1.116E-02 | 1.224E-02 | 1.274E-02 |
| 147.5 | 9.986E-03 | 1.023E-02 | 1.092E-02 | 1.222E-02 | 1.276E-02 |
| 150.0 | 1.044E-02 | 1.055E-02 | 1.122E-02 | 1.264E-02 | 1.318E-02 |
| 152.5 | 1.062E-02 | 1.074E-02 | 1.142E-02 | 1.284E-02 | 1.340E-02 |
| 155.0 | 1.097E-02 | 1.108E-02 | 1.174E-02 | 1.317E-02 | 1.375E-02 |
| 156.0 | 1.098E-02 | 1.107E-02 | 1.173E-02 | 1.320E-02 | 1.378E-02 |
| 157.0 | 1.113E-02 | 1.114E-02 | 1.175E-02 | 1.335E-02 | 1.393E-02 |
| 158.0 | 1.150E-02 | 1.129E-02 | 1.194E-02 | 1.367E-02 | 1.425E-02 |
| 159.0 | 1.187E-02 | 1.145E-02 | 1.210E-02 | 1.403E-02 | 1.461E-02 |
| 160.0 | 1.212E-02 | 1.159E-02 | 1.224E-02 | 1.428E-02 | 1.485E-02 |
| 161.0 | 1.221E-02 | 1.177E-02 | 1.242E-02 | 1.437E-02 | 1.494E-02 |
| 162.0 | 1.220E-02 | 1.199E-02 | 1.262E-02 | 1.437E-02 | 1.495E-02 |
| 163.0 | 1.225E-02 | 1.212E-02 | 1.276E-02 | 1.443E-02 | 1.499E-02 |
| 164.0 | 1.238E-02 | 1.226E-02 | 1.289E-02 | 1.456E-02 | 1.512E-02 |
| 165.0 | 1.256E-02 | 1.248E-02 | 1.309E-02 | 1.472E-02 | 1.531E-02 |
| 166.0 | 1.282E-02 | 1.274E-02 | 1.334E-02 | 1.495E-02 | 1.555E-02 |
| 167.0 | 1.312E-02 | 1.299E-02 | 1.358E-02 | 1.525E-02 | 1.583E-02 |
| 168.0 | 1.338E-02 | 1.317E-02 | 1.376E-02 | 1.550E-02 | 1.609E-02 |
| 169.0 | 1.350E-02 | 1.327E-02 | 1.387E-02 | 1.559E-02 | 1.618E-02 |
| 170.0 | 1.336E-02 | 1.330E-02 | 1.388E-02 | 1.547E-02 | 1.604E-02 |
| 171.0 | 1.298E-02 | 1.317E-02 | 1.377E-02 | 1.512E-02 | 1.571E-02 |
| 172.0 | 1.256E-02 | 1.288E-02 | 1.347E-02 | 1.473E-02 | 1.535E-02 |
| 173.0 | 1.229E-02 | [illegible] | 1.315E-02 | 1.449E-02 | 1.507E-02 |
| 174.0 | 1.222E-02 | 1.234E-02 | 1.297E-02 | 1.439E-02 | 1.498E-02 |
| 175.0 | 1.235E-02 | 1.240E-02 | 1.301E-02 | 1.450E-02 | 1.512E-02 |
| 176.0 | 1.267E-02 | 1.280E-02 | 1.342E-02 | 1.483E-02 | 1.540E-02 |
| 177.0 | 1.314E-02 | 1.351E-02 | 1.407E-02 | 1.515E-02 | 1.566E-02 |
| 178.0 | 1.372E-02 | 1.419E-02 | 1.472E-02 | 1.550E-02 | 1.605E-02 |
| 179.0 | 1.407E-02 | 1.495E-02 | 1.549E-02 | 1.608E-02 | 1.665E-02 |
| 180.0 | 1.455E-02 | 1.542E-02 | 1.594E-02 | 1.643E-02 | 1.697E-02 |

TABLE III-F. NORMALIZED VOLUME SCATTERING FUNCTION : HAZE C MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 7.270E 00 | 4.627E 00 | 4.161E 00 | 3.811E 00 | 3.493E 00 |
| 1.0 | 5.606E 00 | 4.089E 00 | 3.736E 00 | 3.513E 00 | 3.261E 00 |
| 2.0 | 3.468E 00 | 3.034E 00 | 2.859E 00 | 2.837E 00 | 2.713E 00 |
| 3.0 | 2.525E 00 | 2.247E 00 | 2.143E 00 | 2.183E 00 | 2.142E 00 |
| 4.0 | 2.016E 00 | 1.815E 00 | 1.727E 00 | 1.749E 00 | 1.728E 00 |
| 5.0 | 1.696E 00 | 1.533E 00 | 1.464E 00 | 1.485E 00 | 1.466E 00 |
| 6.0 | 1.469E 00 | 1.326E 00 | 1.270E 00 | 1.298E 00 | 1.283E 00 |
| 7.0 | 1.298E 00 | 1.172E 00 | 1.125E 00 | 1.151E 00 | 1.138E 00 |
| 8.0 | 1.163E 00 | 1.051E 00 | 1.009E 00 | 1.036E 00 | 1.022E 00 |
| 9.0 | 1.059E 00 | 9.538E-01 | 9.164E-01 | 9.450E-01 | 9.332E-01 |
| 10.0 | 9.744E-01 | 8.752E-01 | 8.427E-01 | 8.731E-01 | 8.638E-01 |
| 11.0 | 9.050E-01 | 8.149E-01 | 7.861E-01 | 8.167E-01 | 8.082E-01 |
| 12.0 | 8.519E-01 | 7.678E-01 | 7.412E-01 | 7.688E-01 | 7.604E-01 |
| 13.0 | 7.994E-01 | 7.222E-01 | 6.978E-01 | 7.212E-01 | 7.135E-01 |
| 14.0 | 7.380E-01 | 6.733E-01 | 6.516E-01 | 6.715E-01 | 6.648E-01 |
| 15.0 | 6.870E-01 | 6.261E-01 | 6.070E-01 | 6.233E-01 | 6.175E-01 |
| 16.0 | 6.362E-01 | 5.866E-01 | 5.690E-01 | 5.819E-01 | 5.765E-01 |
| 17.0 | 5.970E-01 | 5.532E-01 | 5.373E-01 | 5.486E-01 | 5.432E-01 |
| 18.0 | 5.640E-01 | 5.227E-01 | 5.087E-01 | 5.204E-01 | 5.152E-01 |
| 19.0 | 5.336E-01 | 4.954E-01 | 4.825E-01 | 4.940E-01 | 4.895E-01 |
| 20.0 | 5.051E-01 | 4.704E-01 | 4.586E-01 | 4.687E-01 | 4.647E-01 |
| 22.5 | 4.387E-01 | 4.107E-01 | 4.019E-01 | 4.111E-01 | 4.075E-01 |
| 25.0 | 3.781E-01 | 3.586E-01 | 3.523E-01 | 3.581E-01 | 3.554E-01 |
| 27.5 | 3.269E-01 | 3.156E-01 | 3.110E-01 | 3.129E-01 | 3.108E-01 |
| 30.0 | 2.857E-01 | 2.796E-01 | 2.764E-01 | 2.763E-01 | 2.744E-01 |
| 32.5 | 2.479E-01 | 2.468E-01 | 2.450E-01 | 2.428E-01 | 2.416E-01 |
| 35.0 | 2.127E-01 | 2.181E-01 | 2.174E-01 | 2.112E-01 | 2.102E-01 |
| 37.5 | 1.853E-01 | 1.929E-01 | 1.931E-01 | 1.865E-01 | 1.858E-01 |
| 40.0 | 1.628E-01 | 1.706E-01 | 1.715E-01 | 1.658E-01 | 1.655E-01 |
| 42.5 | 1.409E-01 | 1.512E-01 | 1.525E-01 | 1.458E-01 | 1.455E-01 |
| 45.0 | 1.232E-01 | 1.336E-01 | 1.354E-01 | 1.293E-01 | 1.292E-01 |
| 47.5 | 1.090E-01 | 1.182E-01 | 1.204E-01 | 1.158E-01 | 1.159E-01 |
| 50.0 | 9.527E-02 | 1.054E-01 | 1.078E-01 | 1.028E-01 | 1.030E-01 |
| 52.5 | 8.336E-02 | 9.324E-02 | 9.580E-02 | 9.138E-02 | 9.162E-02 |
| 55.0 | 7.361E-02 | 8.266E-02 | 8.531E-02 | 8.178E-02 | 8.214E-02 |
| 57.5 | 6.562E-02 | 7.453E-02 | 7.716E-02 | 7.375E-02 | 7.413E-02 |
| 60.0 | 5.704E-02 | 6.589E-02 | 6.855E-02 | 6.520E-02 | 6.564E-02 |
| 62.5 | 5.111E-02 | 5.924E-02 | 6.183E-02 | 5.900E-02 | 5.951E-02 |
| 65.0 | 4.561E-02 | 5.306E-02 | 5.558E-02 | 5.330E-02 | 5.382E-02 |
| 67.5 | 4.063E-02 | 4.772E-02 | 5.016E-02 | 4.806E-02 | 4.858E-02 |
| 70.0 | 3.625E-02 | 4.307E-02 | 4.541E-02 | 4.337E-02 | 4.392E-02 |
| 72.5 | 3.264E-02 | 3.873E-02 | 4.097E-02 | 3.941E-02 | 3.998E-02 |
| 75.0 | 2.966E-02 | 3.526E-02 | 3.738E-02 | 3.605E-02 | 3.659E-02 |
| 77.5 | 2.658E-02 | 3.197E-02 | 3.397E-02 | 3.267E-02 | 3.322E-02 |
| 80.0 | 2.430E-02 | 2.911E-02 | 3.099E-02 | 3.003E-02 | 3.059E-02 |
| 82.5 | 2.240E-02 | 2.672E-02 | 2.848E-02 | 2.774E-02 | 2.829E-02 |
| 85.0 | 2.046E-02 | 2.444E-02 | 2.610E-02 | 2.548E-02 | 2.603E-02 |
| 87.5 | 1.858E-02 | 2.223E-02 | 2.379E-02 | 2.334E-02 | 2.390E-02 |
| 90.0 | 1.687E-02 | 2.017E-02 | 2.166E-02 | 2.142E-02 | 2.199E-02 |
| 92.5 | 1.555E-02 | 1.864E-02 | 2.003E-02 | 1.987E-02 | 2.045E-02 |

TABLE III-F. NORMALIZED VOLUME SCATTERING FUNCTION : HAZE C MODEL
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.466E-02 | 1.741E-02 | 1.871E-02 | 1.873E-02 | 1.931E-02 |
| 97.5 | 1.409E-02 | 1.653E-02 | 1.774E-02 | 1.791E-02 | 1.849E-02 |
| 100.0 | 1.328E-02 | 1.551E-02 | 1.665E-02 | 1.692E-02 | 1.750E-02 |
| 102.5 | 1.255E-02 | 1.455E-02 | 1.563E-02 | 1.603E-02 | 1.661E-02 |
| 105.0 | 1.186E-02 | 1.368E-02 | 1.471E-02 | 1.521E-02 | 1.581E-02 |
| 107.5 | 1.112E-02 | 1.274E-02 | 1.374E-02 | 1.437E-02 | 1.499E-02 |
| 110.0 | 1.060E-02 | 1.213E-02 | 1.308E-02 | 1.376E-02 | 1.438E-02 |
| 112.5 | 1.038E-02 | 1.172E-02 | 1.263E-02 | 1.344E-02 | 1.407E-02 |
| 115.0 | 1.024E-02 | 1.143E-02 | 1.229E-02 | 1.321E-02 | 1.385E-02 |
| 117.5 | 1.010E-02 | 1.124E-02 | 1.207E-02 | 1.299E-02 | 1.364E-02 |
| 120.0 | 1.017E-02 | 1.114E-02 | 1.194E-02 | 1.298E-02 | 1.364E-02 |
| 122.5 | 1.025E-02 | 1.108E-02 | 1.184E-02 | 1.300E-02 | 1.367E-02 |
| 125.0 | 1.027E-02 | 1.103E-02 | 1.176E-02 | 1.298E-02 | 1.367E-02 |
| 127.5 | 1.045E-02 | 1.103E-02 | 1.175E-02 | 1.310E-02 | 1.380E-02 |
| 130.0 | 1.062E-02 | 1.109E-02 | 1.178E-02 | 1.325E-02 | 1.396E-02 |
| 132.5 | 1.086E-02 | 1.128E-02 | 1.195E-02 | 1.345E-02 | 1.417E-02 |
| 135.0 | 1.115E-02 | 1.163E-02 | 1.227E-02 | 1.370E-02 | 1.444E-02 |
| 137.5 | 1.150E-02 | 1.207E-02 | 1.268E-02 | 1.402E-02 | 1.476E-02 |
| 140.0 | 1.215E-02 | 1.265E-02 | 1.322E-02 | 1.460E-02 | 1.535E-02 |
| 142.5 | 1.292E-02 | 1.329E-02 | 1.383E-02 | 1.528E-02 | 1.605E-02 |
| 145.0 | 1.373E-02 | 1.395E-02 | 1.445E-02 | 1.601E-02 | 1.678E-02 |
| 147.5 | 1.502E-02 | 1.494E-02 | 1.539E-02 | 1.715E-02 | 1.792E-02 |
| 150.0 | 1.653E-02 | 1.617E-02 | 1.655E-02 | 1.849E-02 | 1.924E-02 |
| 152.5 | 1.807E-02 | 1.755E-02 | 1.785E-02 | 1.982E-02 | 2.055E-02 |
| 155.0 | 2.035E-02 | 1.941E-02 | 1.962E-02 | 2.171E-02 | 2.243E-02 |
| 156.0 | 2.123E-02 | 2.020E-02 | 2.035E-02 | 2.242E-02 | 2.312E-02 |
| 157.0 | 2.206E-02 | 2.093E-02 | 2.105E-02 | 2.305E-02 | 2.375E-02 |
| 158.0 | 2.303E-02 | 2.169E-02 | 2.173E-02 | 2.378E-02 | 2.445E-02 |
| 159.0 | 2.392E-02 | 2.242E-02 | 2.241E-02 | 2.451E-02 | 2.513E-02 |
| 160.0 | 2.460E-02 | 2.313E-02 | 2.312E-02 | 2.497E-02 | 2.560E-02 |
| 161.0 | 2.493E-02 | 2.381E-02 | 2.374E-02 | 2.525E-02 | 2.593E-02 |
| 162.0 | 2.540E-02 | 2.427E-02 | 2.418E-02 | 2.574E-02 | 2.639E-02 |
| 163.0 | 2.616E-02 | 2.456E-02 | 2.447E-02 | 2.643E-02 | 2.703E-02 |
| 164.0 | 2.648E-02 | 2.486E-02 | 2.473E-02 | 2.690E-02 | 2.753E-02 |
| 165.0 | 2.658E-02 | 2.506E-02 | 2.496E-02 | 2.702E-02 | 2.767E-02 |
| 166.0 | 2.663E-02 | 2.526E-02 | 2.516E-02 | 2.712E-02 | 2.776E-02 |
| 167.0 | 2.714E-02 | 2.565E-02 | 2.551E-02 | 2.751E-02 | 2.816E-02 |
| 168.0 | 2.785E-02 | 2.612E-02 | 2.598E-02 | 2.804E-02 | 2.874E-02 |
| 169.0 | 2.840E-02 | 2.656E-02 | 2.636E-02 | 2.850E-02 | 2.917E-02 |
| 170.0 | 2.897E-02 | 2.701E-02 | 2.680E-02 | 2.898E-02 | 2.954E-02 |
| 171.0 | 2.965E-02 | 2.776E-02 | 2.755E-02 | 2.956E-02 | 3.016E-02 |
| 172.0 | 3.060E-02 | 2.878E-02 | 2.844E-02 | 3.032E-02 | 3.097E-02 |
| 173.0 | 3.164E-02 | 2.981E-02 | 2.948E-02 | 3.126E-02 | 3.178E-02 |
| 174.0 | 3.304E-02 | 3.106E-02 | 3.062E-02 | 3.228E-02 | 3.284E-02 |
| 175.0 | 3.460E-02 | 3.219E-02 | 3.163E-02 | 3.362E-02 | 3.429E-02 |
| 176.0 | 3.610E-02 | 3.334E-02 | 3.284E-02 | 3.486E-02 | 3.526E-02 |
| 177.0 | 3.683E-02 | 3.408E-02 | 3.332E-02 | 3.481E-02 | 3.497E-02 |
| 178.0 | 3.721E-02 | 3.318E-02 | 3.241E-02 | 3.398E-02 | 3.438E-02 |
| 179.0 | 3.521E-02 | 3.265E-02 | 3.213E-02 | 3.410E-02 | 3.470E-02 |
| 180.0 | 3.534E-02 | 3.304E-02 | 3.253E-02 | 3.455E-02 | 3.513E-02 |

TABLE III-G. NORMALIZED VOLUME SCATTERING FUNCTION : $\nu$ = 2.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 5.926E 02 | 2.636E 02 | 1.949E 02 | 1.236E 02 | 1.119E 02 |
| 1.0 | 8.983E 01 | 1.061E 02 | 9.919E 01 | 8.042E 01 | 7.603E 01 |
| 2.0 | 1.507E 01 | 1.878E 01 | 2.029E 01 | 2.465E 01 | 2.569E 01 |
| 3.0 | 5.525E 00 | 7.137E 00 | 8.051E 00 | 8.592E 00 | 8.579E 00 |
| 4.0 | 2.872E 00 | 3.654E 00 | 3.959E 00 | 4.442E 00 | 4.593E 00 |
| 5.0 | 1.670E 00 | 2.243E 00 | 2.454E 00 | 2.636E 00 | 2.737E 00 |
| 6.0 | 1.175E 00 | 1.538E 00 | 1.609E 00 | 1.802E 00 | 1.873E 00 |
| 7.0 | 9.031E-01 | 1.064E 00 | 1.194E 00 | 1.245E 00 | 1.234E 00 |
| 8.0 | 6.797E-01 | 8.071E-01 | 8.494E-01 | 8.970E-01 | 9.341E-01 |
| 9.0 | 5.714E-01 | 6.366E-01 | 6.619E-01 | 8.130E-01 | 8.279E-01 |
| 10.0 | 4.904E-01 | 5.541E-01 | 5.825E-01 | 5.865E-01 | 5.873E-01 |
| 11.0 | 4.596E-01 | 3.975E-01 | 3.860E-01 | 4.313E-01 | 4.438E-01 |
| 12.0 | 3.628E-01 | 4.439E-01 | 4.954E-01 | 5.878E-01 | 6.039E-01 |
| 13.0 | 5.681E-01 | 6.206E-01 | 6.285E-01 | 6.859E-01 | 6.857E-01 |
| 14.0 | 3.565E-01 | 3.471E-01 | 3.766E-01 | 4.616E-01 | 4.767E-01 |
| 15.0 | 3.133E-01 | 3.591E-01 | 3.387E-01 | 3.162E-01 | 3.171E-01 |
| 16.0 | 3.031E-01 | 3.034E-01 | 3.336E-01 | 3.363E-01 | 3.328E-01 |
| 17.0 | 2.986E-01 | 3.186E-01 | 3.074E-01 | 3.032E-01 | 3.138E-01 |
| 18.0 | 2.835E-01 | 2.807E-01 | 2.966E-01 | 2.927E-01 | 2.906E-01 |
| 19.0 | 2.785E-01 | 2.987E-01 | 2.879E-01 | 3.093E-01 | 3.067E-01 |
| 20.0 | 2.658E-01 | 2.775E-01 | 2.882E-01 | 2.861E-01 | 2.925E-01 |
| 22.5 | 2.427E-01 | 2.479E-01 | 2.529E-01 | 2.560E-01 | 2.627E-01 |
| 25.0 | 1.998E-01 | 2.213E-01 | 2.196E-01 | 2.152E-01 | 2.206E-01 |
| 27.5 | 1.874E-01 | 2.034E-01 | 2.039E-01 | 1.937E-01 | 1.961E-01 |
| 30.0 | 1.825E-01 | 1.830E-01 | 1.878E-01 | 1.878E-01 | 1.895E-01 |
| 32.5 | 1.578E-01 | 1.547E-01 | 1.562E-01 | 1.640E-01 | 1.656E-01 |
| 35.0 | 1.499E-01 | 1.238E-01 | 1.209E-01 | 1.436E-01 | 1.445E-01 |
| 37.5 | 1.335E-01 | 1.125E-01 | 1.105E-01 | 1.255E-01 | 1.259E-01 |
| 40.0 | 1.134E-01 | 1.113E-01 | 1.137E-01 | 1.139E-01 | 1.145E-01 |
| 42.5 | 9.748E-02 | 9.840E-02 | 9.979E-02 | 9.700E-02 | 9.758E-02 |
| 45.0 | 8.473E-02 | 8.829E-02 | 8.672E-02 | 8.726E-02 | 8.772E-02 |
| 47.5 | 7.818E-02 | 7.358E-02 | 7.554E-02 | 8.057E-02 | 8.058E-02 |
| 50.0 | 6.420E-02 | 6.916E-02 | 6.982E-02 | 6.874E-02 | 6.807E-02 |
| 52.5 | 5.925E-02 | 5.946E-02 | 5.959E-02 | 5.937E-02 | 5.852E-02 |
| 55.0 | 4.925E-02 | 5.234E-02 | 5.093E-02 | 4.617E-02 | 4.575E-02 |
| 57.5 | 4.072E-02 | 4.378E-02 | 4.651E-02 | 5.066E-02 | 5.174E-02 |
| 60.0 | 3.939E-02 | 4.104E-02 | 3.986E-02 | 3.904E-02 | 3.954E-02 |
| 62.5 | 3.595E-02 | 3.640E-02 | 3.675E-02 | 3.561E-02 | 3.588E-02 |
| 65.0 | 3.089E-02 | 3.257E-02 | 3.247E-02 | 3.334E-02 | 3.389E-02 |
| 67.5 | 2.456E-02 | 2.537E-02 | 2.629E-02 | 2.772E-02 | 2.768E-02 |
| 70.0 | 2.186E-02 | 2.361E-02 | 2.464E-02 | 2.452E-02 | 2.410E-02 |
| 72.5 | 1.954E-02 | 2.063E-02 | 2.096E-02 | 2.281E-02 | 2.295E-02 |
| 75.0 | 1.783E-02 | 1.894E-02 | 1.949E-02 | 2.048E-02 | 2.090E-02 |
| 77.5 | 1.283E-02 | 1.469E-02 | 1.545E-02 | 1.608E-02 | 1.619E-02 |
| 80.0 | 1.281E-02 | 1.420E-02 | 1.429E-02 | 1.551E-02 | 1.572E-02 |
| 82.5 | 1.211E-02 | 1.278E-02 | 1.407E-02 | 1.506E-02 | 1.545E-02 |
| 85.0 | 1.152E-02 | 1.052E-02 | 1.120E-02 | 1.471E-02 | 1.507E-02 |
| 87.5 | 1.102E-02 | 1.190E-02 | 1.176E-02 | 1.305E-02 | 1.319E-02 |
| 90.0 | 8.968E-03 | 9.541E-03 | 9.682E-03 | 1.053E-02 | 1.045E-02 |
| 92.5 | 7.675E-03 | 8.594E-03 | 8.800E-03 | 9.238E-03 | 9.159E-03 |

TABLE III-G. NORMALIZED VOLUME SCATTERING FUNCTION : ν = 2.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 5.651E-03 | 6.721E-03 | 7.017E-03 | 7.567E-03 | 7.622E-03 |
| 97.5 | 5.713E-03 | 6.707E-03 | 7.250E-03 | 7.631E-03 | 7.873E-03 |
| 100.0 | 4.548E-03 | 5.446E-03 | 5.810E-03 | 6.400E-03 | 6.504E-03 |
| 102.5 | 3.766E-03 | 4.741E-03 | 5.139E-03 | 5.482E-03 | 5.524E-03 |
| 105.0 | 3.816E-03 | 4.593E-03 | 4.988E-03 | 5.373E-03 | 5.473E-03 |
| 107.5 | 4.069E-03 | 4.145E-03 | 4.328E-03 | 4.909E-03 | 4.954E-03 |
| 110.0 | 3.546E-03 | 3.779E-03 | 4.225E-03 | 4.960E-03 | 5.085E-03 |
| 112.5 | 3.638E-03 | 3.856E-03 | 3.910E-03 | 4.882E-03 | 4.999E-03 |
| 115.0 | 3.725E-03 | 3.854E-03 | 4.141E-03 | 4.993E-03 | 5.080E-03 |
| 117.5 | 3.214E-03 | 3.520E-03 | 3.738E-03 | 4.375E-03 | 4.454E-03 |
| 120.0 | 3.479E-03 | 3.264E-03 | 3.565E-03 | 4.247E-03 | 4.331E-03 |
| 122.5 | 3.033E-03 | 3.338E-03 | 3.557E-03 | 4.237E-03 | 4.325E-03 |
| 125.0 | 2.754E-03 | 3.349E-03 | 3.560E-03 | 3.831E-03 | 3.871E-03 |
| 127.5 | 2.900E-03 | 3.190E-03 | 3.340E-03 | 3.328E-03 | 3.918E-03 |
| 130.0 | 2.951E-03 | 3.176E-03 | 3.427E-03 | 3.875E-03 | 3.995E-03 |
| 132.5 | 3.236E-03 | 3.220E-03 | 3.382E-03 | 3.980E-03 | 4.045E-03 |
| 135.0 | 2.914E-03 | 3.611E-03 | 3.793E-03 | 4.221E-03 | 4.380E-03 |
| 137.5 | 3.461E-03 | 3.688E-03 | 4.061E-03 | 4.980E-03 | 5.101E-03 |
| 140.0 | 3.550E-03 | 3.885E-03 | 4.250E-03 | 5.088E-03 | 5.265E-03 |
| 142.5 | 3.672E-03 | 4.394E-03 | 4.826E-03 | 5.491E-03 | 5.588E-03 |
| 145.0 | 4.116E-03 | 4.560E-03 | 4.744E-03 | 5.396E-03 | 5.502E-03 |
| 147.5 | 4.735E-03 | 5.945E-03 | 6.423E-03 | 6.896E-03 | 7.124E-03 |
| 150.0 | 5.621E-03 | 6.838E-03 | 7.605E-03 | 9.403E-03 | 9.676E-03 |
| 152.5 | 8.455E-03 | 1.050E-02 | 1.123E-02 | 1.258E-02 | 1.283E-02 |
| 155.0 | 1.618E-02 | 1.937E-02 | 2.063E-02 | 2.311E-02 | 2.325E-02 |
| 156.0 | 2.437E-02 | 2.657E-02 | 2.635E-02 | 2.755E-02 | 2.773E-02 |
| 157.0 | 3.504E-02 | 3.364E-02 | 3.311E-02 | 3.169E-02 | 3.126E-02 |
| 158.0 | 5.115E-02 | 4.487E-02 | 4.355E-02 | 3.995E-02 | 4.011E-02 |
| 159.0 | 6.337E-02 | 5.512E-02 | 5.074E-02 | 4.885E-02 | 4.819E-02 |
| 160.0 | 6.970E-02 | 6.214E-02 | 5.859E-02 | 5.464E-02 | 5.352E-02 |
| 161.0 | 5.684E-02 | 6.197E-02 | 6.160E-02 | 5.418E-02 | 5.322E-02 |
| 162.0 | 4.430E-02 | 5.583E-02 | 5.818E-02 | 5.345E-02 | 5.281E-02 |
| 163.0 | 4.398E-02 | 5.317E-02 | 5.511E-02 | 5.898E-02 | 6.000E-02 |
| 164.0 | 4.600E-02 | 4.256E-02 | 4.520E-02 | 5.416E-02 | 5.451E-02 |
| 165.0 | 4.442E-02 | 4.467E-02 | 4.624E-02 | 4.854E-02 | 4.978E-02 |
| 166.0 | 4.195E-02 | 4.440E-02 | 4.258E-02 | 4.323E-02 | 4.308E-02 |
| 167.0 | 4.579E-02 | 4.738E-02 | 4.806E-02 | 4.615E-02 | 4.657E-02 |
| 168.0 | 4.809E-02 | 4.835E-02 | 5.053E-02 | 5.117E-02 | 5.006E-02 |
| 169.0 | 4.820E-02 | 5.107E-02 | 5.131E-02 | 5.457E-02 | 5.529E-02 |
| 170.0 | 5.135E-02 | 5.182E-02 | 5.280E-02 | 5.564E-02 | 5.530E-02 |
| 171.0 | 5.071E-02 | 5.448E-02 | 5.446E-02 | 5.788E-02 | 5.997E-02 |
| 172.0 | 5.624E-02 | 6.210E-02 | [illegible] | 6.301E-02 | 6.259E-02 |
| 173.0 | 6.384E-02 | 6.310E-02 | [illegible] | 6.964E-02 | 7.172E-02 |
| 174.0 | 6.987E-02 | 7.455E-02 | [illegible] | 7.867E-02 | 7.727E-02 |
| 175.0 | 8.568E-02 | 8.192E-02 | [illegible] | [illegible] | 9.691E-02 |
| 176.0 | 9.683E-02 | 9.538E-02 | 1.016E-01 | 1.097E-01 | 1.080E-01 |
| 177.0 | 1.232E-01 | 1.262E-01 | 1.167E-01 | 1.326E-01 | 1.375E-01 |
| 178.0 | 1.711E-01 | 1.619E-01 | 1.700E-01 | 1.504E-01 | 1.388E-01 |
| 179.0 | 2.697E-01 | 1.124E-01 | 7.857E-02 | 5.471E-02 | 5.206E-02 |
| 180.0 | 7.018E-02 | 4.470E-02 | 4.420E-02 | 4.583E-02 | 4.750E-02 |

TABLE III-H. NORMALIZED VOLUME SCATTERING FUNCTION : $\nu$ = 2.5
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 3.697E 02 | 1.671E 02 | 1.246E 02 | 8.018E 01 | 7.280E 01 |
| 1.0 | 7.102E 01 | 7.379E 01 | 6.765E 01 | 5.423E 01 | 5.119E 01 |
| 2.0 | 1.525E 01 | 1.704E 01 | 1.768E 01 | 1.950E 01 | 1.991E 01 |
| 3.0 | 6.347E 00 | 7.358E 00 | 7.838E 00 | 8.001E 00 | 7.978E 00 |
| 4.0 | 3.513E 00 | 4.093E 00 | 4.284E 00 | 4.495E 00 | 4.577E 00 |
| 5.0 | 2.192E 00 | 2.646E 00 | 2.786E 00 | 2.862E 00 | 2.921E 00 |
| 6.0 | 1.561E 00 | 1.861E 00 | 1.922E 00 | 2.022E 00 | 2.065E 00 |
| 7.0 | 1.186E 00 | 1.343E 00 | 1.433E 00 | 1.465E 00 | 1.466E 00 |
| 8.0 | 9.051E-01 | 1.023E 00 | 1.061E 00 | 1.107E 00 | 1.133E 00 |
| 9.0 | 7.522E-01 | 8.146E-01 | 8.419E-01 | 9.485E-01 | 9.599E-01 |
| 10.0 | 6.347E-01 | 6.862E-01 | 7.108E-01 | 7.456E-01 | 7.504E-01 |
| 11.0 | 5.760E-01 | 5.487E-01 | 5.553E-01 | 6.216E-01 | 6.335E-01 |
| 12.0 | 5.243E-01 | 5.770E-01 | 6.140E-01 | 6.972E-01 | 7.088E-01 |
| 13.0 | 6.428E-01 | 6.682E-01 | 6.749E-01 | 7.277E-01 | 7.287E-01 |
| 14.0 | 4.515E-01 | 4.623E-01 | 4.865E-01 | 5.520E-01 | 5.625E-01 |
| 15.0 | 3.857E-01 | 4.[illegible]29E-01 | 4.175E-01 | 4.175E-01 | 4.207E-01 |
| 16.0 | 3.564E-01 | 3.711E-01 | 3.921E-01 | 3.962E-01 | 3.961E-01 |
| 17.0 | 3.409E-01 | 3.645E-01 | 3.624E-01 | 3.636E-01 | 3.709E-01 |
| 18.0 | 3.249E-01 | 3.329E-01 | 3.454E-01 | 3.489E-01 | 3.494E-01 |
| 19.0 | 3.173E-01 | 3.366E-01 | 3.339E-01 | 3.507E-01 | 3.504E-01 |
| 20.0 | 3.036E-01 | 3.182E-01 | 3.271E-01 | 3.305E-01 | 3.352E-01 |
| 22.5 | 2.718E-01 | 2.782E-01 | 2.832E-01 | 2.911E-01 | 2.957E-01 |
| 25.0 | 2.246E-01 | 2.416E-01 | 2.423E-01 | 2.440E-01 | 2.477E-01 |
| 27.5 | 2.034E-01 | 2.174E-01 | 2.186E-01 | 2.139E-01 | 2.158E-01 |
| 30.0 | 1.946E-01 | 1.955E-01 | 1.991E-01 | 2.020E-01 | 2.033E-01 |
| 32.5 | 1.695E-01 | 1.662E-01 | 1.678E-01 | 1.772E-01 | 1.784E-01 |
| 35.0 | 1.512E-01 | 1.377E-01 | 1.374E-01 | 1.506E-01 | 1.513E-01 |
| 37.5 | 1.346E-01 | 1.238E-01 | 1.237E-01 | 1.326E-01 | 1.330E-01 |
| 40.0 | 1.191E-01 | 1.167E-01 | 1.182E-01 | 1.214E-01 | 1.219E-01 |
| 42.5 | 1.009E-01 | 1.039E-01 | 1.051E-01 | 1.024E-01 | 1.028E-01 |
| 45.0 | 8.814E-02 | 9.211E-02 | 9.157E-02 | 9.150E-02 | 9.185E-02 |
| 47.5 | 8.195E-02 | 7.864E-02 | 8.009E-02 | 8.494E-02 | 8.505E-02 |
| 50.0 | 6.870E-02 | 7.348E-02 | 7.411E-02 | 7.301E-02 | 7.276E-02 |
| 52.5 | 6.184E-02 | 6.327E-02 | 6.367E-02 | 6.320E-02 | 6.286E-02 |
| 55.0 | 5.269E-02 | 5.442E-02 | 5.388E-02 | 5.232E-02 | 5.227E-02 |
| 57.5 | 4.671E-02 | 4.966E-02 | 5.152E-02 | 5.424E-02 | 5.491E-02 |
| 60.0 | 4.154E-02 | 4.344E-02 | 4.301E-02 | 4.241E-02 | 4.277E-02 |
| 62.5 | 3.839E-02 | 3.945E-02 | 3.991E-02 | 3.937E-02 | 3.962E-02 |
| 65.0 | 3.378E-02 | 3.523E-02 | 3.537E-02 | 3.638E-02 | 3.675E-02 |
| 67.5 | 2.802E-02 | 2.918E-02 | 2.996E-02 | 3.101E-02 | 3.108E-02 |
| 70.0 | 2.473E-02 | 2.683E-02 | 2.759E-02 | 2.731E-02 | 2.716E-02 |
| 72.5 | 2.234E-02 | 2.340E-02 | 2.379E-02 | 2.523E-02 | 2.537E-02 |
| 75.0 | 2.066E-02 | 2.163E-02 | 2.212E-02 | 2.311E-02 | 2.341E-02 |
| 77.5 | 1.597E-02 | 1.797E-02 | 1.861E-02 | 1.888E-02 | 1.901E-02 |
| 80.0 | 1.547E-02 | 1.678E-02 | 1.703E-02 | 1.799E-02 | 1.817E-02 |
| 82.5 | 1.467E-02 | 1.549E-02 | 1.637E-02 | 1.720E-02 | 1.747E-02 |
| 85.0 | 1.369E-02 | 1.342E-02 | 1.400E-02 | 1.621E-02 | 1.644E-02 |
| 87.5 | 1.281E-02 | 1.349E-02 | 1.354E-02 | 1.446E-02 | 1.457E-02 |
| 90.0 | 1.066E-02 | 1.127E-02 | 1.149E-02 | 1.223E-02 | 1.223E-02 |
| 92.5 | 9.377E-03 | 1.032E-02 | 1.056E-02 | 1.090E-02 | 1.090E-02 |

TABLE III-H. NORMALIZED VOLUME SCATTERING FUNCTION : $\nu$ = 2.5
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 7.691E-03 | 8.697E-03 | 9.002E-03 | 9.489E-03 | 9.572E-03 |
| 97.5 | 7.783E-03 | 8.744E-03 | 9.190E-03 | 9.584E-03 | 9.765E-03 |
| 100.0 | 6.591E-03 | 7.552E-03 | 7.905E-03 | 8.404E-03 | 8.514E-03 |
| 102.5 | 5.844E-03 | 6.823E-03 | 7.193E-03 | 7.587E-03 | 7.667E-03 |
| 105.0 | 5.732E-03 | 6.568E-03 | 6.927E-03 | 7.336E-03 | 7.443E-03 |
| 107.5 | 5.528E-03 | 5.733E-03 | 5.954E-03 | 6.605E-03 | 6.676E-03 |
| 110.0 | 5.019E-03 | 5.463E-03 | 5.825E-03 | 6.410E-03 | 6.516E-03 |
| 112.5 | 5.103E-03 | 5.414E-03 | 5.567E-03 | 6.396E-03 | 6.500E-03 |
| 115.0 | 5.151E-03 | 5.342E-03 | 5.606E-03 | 6.401E-03 | 6.485E-03 |
| 117.5 | 4.613E-03 | 5.072E-03 | 5.309E-03 | 5.830E-03 | 5.911E-03 |
| 120.0 | 4.814E-03 | 4.896E-03 | 5.181E-03 | 5.822E-03 | 5.909E-03 |
| 122.5 | 4.551E-03 | 4.969E-03 | 5.213E-03 | 5.841E-03 | 5.632E-03 |
| 125.0 | 4.258E-03 | 4.654E-03 | 5.188E-03 | 5.473E-03 | 5.540E-03 |
| 127.5 | 4.433E-03 | 4.864E-03 | 5.075E-03 | 5.614E-03 | 5.710E-03 |
| 130.0 | 4.502E-03 | 4.860E-03 | 5.122E-03 | 5.713E-03 | 5.826E-03 |
| 132.5 | 4.795E-03 | 4.945E-03 | 5.166E-03 | 5.889E-03 | 5.976E-03 |
| 135.0 | 4.718E-03 | 5.388E-03 | 5.622E-03 | 6.170E-03 | 6.308E-03 |
| 137.5 | 5.235E-03 | 5.650E-03 | 5.999E-03 | 6.745E-03 | 6.858E-03 |
| 140.0 | 5.607E-03 | 6.100E-03 | 6.462E-03 | 7.294E-03 | 7.449E-03 |
| 142.5 | 6.009E-03 | 6.769E-03 | 7.181E-03 | 7.931E-03 | 8.049E-03 |
| 145.0 | 6.417E-03 | 7.117E-03 | 7.416E-03 | 8.132E-03 | 8.263E-02 |
| 147.5 | 7.589E-03 | 8.824E-03 | 9.296E-03 | 9.920E-03 | 1.012E-02 |
| 150.0 | 9.248E-03 | 1.042E-02 | 1.110E-02 | 1.265E-02 | 1.288E-02 |
| 152.5 | 1.216E-02 | 1.394E-02 | 1.459E-02 | 1.577E-02 | 1.599E-02 |
| 155.0 | 1.988E-02 | 2.188E-02 | 2.273E-02 | 2.466E-02 | 2.478E-02 |
| 156.0 | 2.609E-02 | 2.728E-02 | 2.721E-02 | 2.816E-02 | 2.827E-02 |
| 157.0 | 3.356E-02 | 3.260E-02 | 3.227E-02 | 3.142E-02 | 3.119E-02 |
| 158.0 | 4.508E-02 | 4.057E-02 | 3.958E-02 | 3.746E-02 | 3.748E-02 |
| 159.0 | 5.415E-02 | 4.800E-02 | 4.516E-02 | 4.406E-02 | 4.358E-02 |
| 160.0 | 5.973E-02 | 5.342E-02 | 5.093E-02 | 4.824E-02 | 4.747E-02 |
| 161.0 | 5.221E-02 | 5.489E-02 | 5.415E-02 | 4.809E-02 | 4.742E-02 |
| 162.0 | 4.520E-02 | 5.191E-02 | 5.278E-02 | 4.850E-02 | 4.803E-02 |
| 163.0 | 4.618E-02 | 5.041E-02 | 5.114E-02 | 5.325E-02 | 5.363E-02 |
| 164.0 | 4.659E-02 | [illegible].423E-02 | 4.572E-02 | 5.117E-02 | 5.127E-02 |
| 165.0 | 4.527E-02 | 4.[illegible]22E-02 | 4.606E-02 | 4.764E-02 | 4.827E-02 |
| 166.0 | 4.328E-02 | 4.471E-02 | 4.379E-02 | 4.412E-02 | 4.407E-02 |
| 167.0 | 4.671E-02 | 4.701E-02 | 4.735E-02 | 4.626E-02 | 4.649E-02 |
| 168.0 | 4.870E-02 | 4.845E-02 | 4.959E-02 | 5.015E-02 | 4.954E-02 |
| 169.0 | 4.921E-02 | 5.040E-02 | 5.072E-02 | 5.257E-02 | 5.290E-02 |
| 170.0 | 5.176E-02 | 5.104E-02 | 5.150E-02 | 5.357E-02 | 5.334E-02 |
| 171.0 | 5.190E-02 | 5.350E-02 | 5.336E-02 | 5.581E-02 | 5.685E-02 |
| 172.0 | 5.666E-02 | 5.961E-02 | 5.968E-02 | 5.972E-02 | 5.941E-02 |
| 173.0 | 6.274E-02 | 6.197E-02 | 6.347E-02 | 6.478E-02 | 6.574E-02 |
| 174.0 | 6.866E-02 | 7.050E-02 | 6.977E-02 | 7.185E-02 | 7.091E-02 |
| 175.0 | 8.155E-02 | 7.702E-02 | 7.872E-02 | 8.293E-02 | 8.427E-02 |
| 176.0 | 9.081E-02 | 8.714E-02 | 8.976E-02 | 9.350E-02 | 9.216E-02 |
| 177.0 | 1.081E-01 | 1.052E-01 | 9.857E-02 | 1.058E-01 | 1.077E-01 |
| 178.0 | 1.358E-01 | 1.231E-01 | 1.240E-01 | 1.093E-01 | 1.020E-01 |
| 179.0 | 1.787E-01 | 8.407E-02 | 6.455E-02 | 5.162E-02 | 5.013E-02 |
| 180.0 | 6.043E-02 | 4.588E-02 | 4.560E-02 | 4.733E-02 | 4.826E-02 |

TABLE III-1. NORMALIZED VOLUME SCATTERING FUNCTION: $\nu$ = 3.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 1.592E 02 | 7.744E 01 | 5.948E 01 | 4.013E 01 | 3.681E 01 |
| 1.0 | 3.993E 01 | 3.826E 01 | 3.500E 01 | 2.850E 01 | 2.703E 01 |
| 2.0 | 1.151E 01 | 1.184E 01 | 1.192E 01 | 1.229E 01 | 1.237E 01 |
| 3.0 | 5.666E 00 | 6.003E 00 | 6.136E 00 | 6.060E 00 | 6.030E 00 |
| 4.0 | 3.494E 00 | 3.738E 00 | 3.797E 00 | 3.801E 00 | 3.825E 00 |
| 5.0 | 2.403E 00 | 2.616E 00 | 2.666E 00 | 2.648E 00 | 2.669E 00 |
| 6.0 | 1.803E 00 | 1.951E 00 | 1.976E 00 | 1.989E 00 | 2.006E 00 |
| 7.0 | 1.419E 00 | 1.501E 00 | 1.539E 00 | 1.542E 00 | 1.543E 00 |
| 8.0 | 1.139E 00 | 1.197E 00 | 1.216E 00 | 1.239E 00 | 1.250E 00 |
| 9.0 | 9.647E-01 | 9.912E-01 | 1.006E 00 | 1.062E 00 | 1.068E 00 |
| 10.0 | 8.331E-01 | 8.495E-01 | 8.630E-01 | 8.988E-01 | 9.073E-01 |
| 11.0 | 7.534E-01 | 7.352E-01 | 7.431E-01 | 7.961E-01 | 8.026E-01 |
| 12.0 | 7.094E-01 | 7.191E-01 | 7.367E-01 | 7.925E-01 | 7.980E-01 |
| 13.0 | 7.267E-01 | 7.247E-01 | 7.291E-01 | 7.660E-01 | 7.668E-01 |
| 14.0 | 5.870E-01 | 5.919E-01 | 6.044E-01 | 6.430E-01 | 6.481E-01 |
| 15.0 | 5.093E-01 | 5.279E-01 | 5.290E-01 | 5.371E-01 | 5.396E-01 |
| 16.0 | 4.622E-01 | 4.758E-01 | 4.865E-01 | 4.914E-01 | 4.923E-01 |
| 17.0 | 4.328E-01 | 4.486E-01 | 4.503E-01 | 4.543E-01 | 4.582E-01 |
| 18.0 | 4.100E-01 | 4.172E-01 | 4.243E-01 | 4.308E-01 | 4.318E-01 |
| 19.0 | 3.935E-01 | 4.039E-01 | 4.047E-01 | 4.165E-01 | 4.171E-01 |
| 20.0 | 3.748E-01 | 3.828E-01 | 3.880E-01 | 3.943E-01 | 3.969E-01 |
| 22.5 | 3.283E-01 | 3.299E-01 | 3.333E-01 | 3.430E-01 | 3.454E-01 |
| 25.0 | 2.752E-01 | 2.824E-01 | 2.838E-01 | 2.896E-01 | 2.915E-01 |
| 27.5 | 2.409E-01 | 2.489E-01 | 2.502E-01 | 2.500E-01 | 2.512E-01 |
| 30.0 | 2.212E-01 | 2.218E-01 | 2.239E-01 | 2.274E-01 | 2.282E-01 |
| 32.5 | 1.933E-01 | 1.912E-01 | 1.925E-01 | 1.992E-01 | 2.000E-01 |
| 35.0 | 1.657E-01 | 1.639E-01 | 1.645E-01 | 1.682E-01 | 1.687E-01 |
| 37.5 | 1.467E-01 | 1.454E-01 | 1.460E-01 | 1.483E-01 | 1.487E-01 |
| 40.0 | 1.321E-01 | 1.312E-01 | 1.322E-01 | 1.346E-01 | 1.349E-01 |
| 42.5 | 1.123E-01 | 1.167E-01 | 1.175E-01 | 1.145E-01 | 1.148E-01 |
| 45.0 | 9.868E-02 | 1.027E-01 | 1.028E-01 | 1.016E-01 | 1.019E-01 |
| 47.5 | 9.083E-02 | 8.941E-02 | 9.026E-02 | 9.325E-02 | 9.337E-02 |
| 50.0 | 7.819E-02 | 8.188E-02 | 8.234E-02 | 8.112E-02 | 8.111E-02 |
| 52.5 | 6.912E-02 | 7.114E-02 | 7.152E-02 | 7.072E-02 | 7.067E-02 |
| 55.0 | 6.063E-02 | 6.160E-02 | 6.152E-02 | 6.153E-02 | 6.161E-02 |
| 57.5 | 5.543E-02 | 5.735E-02 | 5.824E-02 | 5.933E-02 | 5.965E-02 |
| 60.0 | 4.747E-02 | 4.928E-02 | 4.929E-02 | 4.869E-02 | 4.890E-02 |
| 62.5 | 4.386E-02 | 4.500E-02 | 4.534E-02 | 4.502E-02 | 4.518E-02 |
| 65.0 | 3.928E-02 | 4.015E-02 | 4.033E-02 | 4.103E-02 | 4.123E-02 |
| 67.5 | 3.408E-02 | 3.505E-02 | 3.551E-02 | 3.600E-02 | 3.608E-02 |
| 70.0 | 3.022E-02 | 3.194E-02 | 3.236E-02 | 3.195E-02 | 3.194E-02 |
| 72.5 | 2.744E-02 | 2.816E-02 | 2.843E-02 | 2.923E-02 | 2.933E-02 |
| 75.0 | 2.540E-02 | 2.602E-02 | 2.633E-02 | 2.693E-02 | 2.709E-02 |
| 77.5 | 2.133E-02 | 2.282E-02 | 2.319E-02 | 2.312E-02 | 2.322E-02 |
| 80.0 | 2.006E-02 | 2.093E-02 | 2.114E-02 | 2.164E-02 | 2.175E-02 |
| 82.5 | 1.889E-02 | 1.946E-02 | 1.989E-02 | 2.038E-02 | 2.052E-02 |
| 85.0 | 1.737E-02 | 1.753E-02 | 1.786E-02 | 1.881E-02 | 1.893E-02 |
| 87.5 | 1.591E-02 | 1.639E-02 | 1.650E-02 | 1.693E-02 | 1.700E-02 |
| 90.0 | 1.387E-02 | 1.428E-02 | 1.445E-02 | 1.492E-02 | 1.496E-02 |
| 92.5 | 1.252E-02 | 1.321E-02 | 1.338E-02 | 1.353E-02 | 1.356E-02 |

TABLE III-1. NORMALIZED VOLUME SCATTERING FUNCTION : ν = 3.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.126E-02 | 1.193E-02 | 1.213E-02 | 1.242E-02 | 1.249E-02 |
| 97.5 | 1.119E-02 | 1.182E-02 | 1.207E-02 | 1.232E-02 | 1.242E-02 |
| 100.0 | 1.010E-02 | 1.077E-02 | 1.099E-02 | 1.127E-02 | 1.135E-02 |
| 102.5 | 9.354E-03 | 9.997E-03 | 1.022E-02 | 1.049E-02 | 1.056E-02 |
| 105.0 | 8.952E-03 | 9.513E-03 | 9.728E-03 | 1.000E-02 | 1.007E-02 |
| 107.5 | 8.308E-03 | 8.481E-03 | 8.641E-03 | 9.125E-03 | 9.180E-03 |
| 110.0 | 7.761E-03 | 8.134E-03 | 8.343E-03 | 8.693E-03 | 8.760E-03 |
| 112.5 | 7.759E-03 | 7.979E-03 | 8.109E-03 | 8.641E-03 | 8.706E-03 |
| 115.0 | 7.719E-03 | 7.844E-03 | 8.011E-03 | 8.563E-03 | 8.620E-03 |
| 117.5 | 7.290E-03 | 7.674E-03 | 7.837E-03 | 8.151E-03 | 8.208E-03 |
| 120.0 | 7.435E-03 | 7.603E-03 | 7.785E-03 | 8.218E-03 | 8.278E-03 |
| 122.5 | 7.357E-03 | 7.662E-03 | 7.828E-03 | 8.275E-03 | 8.337E-03 |
| 125.0 | 7.154E-03 | 7.647E-03 | 7.809E-03 | 8.047E-03 | 8.100E-03 |
| 127.5 | 7.363E-03 | 7.639E-03 | 7.796E-03 | 8.256E-03 | 8.323E-03 |
| 130.0 | 7.487E-03 | 7.668E-03 | 7.844E-03 | 8.407E-03 | 8.481E-03 |
| 132.5 | 7.776E-03 | 7.847E-03 | 8.011E-03 | 8.646E-03 | 8.710E-03 |
| 135.0 | 7.946E-03 | 8.334E-03 | 8.504E-03 | 8.968E-03 | 9.052E-03 |
| 137.5 | 8.388E-03 | 8.785E-03 | 9.003E-03 | 9.413E-03 | 9.486E-03 |
| 140.0 | 9.066E-03 | 9.464E-03 | 9.692E-03 | 1.021E-02 | 1.030E-02 |
| 142.5 | 9.785E-03 | 1.028E-02 | 1.053E-02 | 1.104E-02 | 1.112E-02 |
| 145.0 | 1.039E-02 | 1.090E-02 | 1.112E-02 | 1.162E-02 | 1.171E-02 |
| 147.5 | 1.199E-02 | 1.264E-02 | 1.293E-02 | 1.348E-02 | 1.360E-02 |
| 150.0 | 1.412E-02 | 1.461E-02 | 1.497E-02 | 1.602E-02 | 1.615E-02 |
| 152.5 | 1.679E-02 | 1.759E-02 | 1.793E-02 | 1.873E-02 | 1.885E-02 |
| 155.0 | 2.295E-02 | 2.344E-02 | 2.380E-02 | 2.501E-02 | 2.506E-02 |
| 156.0 | 2.665E-02 | 2.676E-02 | 2.671E-02 | 2.740E-02 | 2.743E-02 |
| 157.0 | 3.070E-02 | 3.001E-02 | 2.982E-02 | 2.961E-02 | 2.950E-02 |
| 158.0 | 3.685E-02 | 3.443E-02 | 3.391E-02 | 3.320E-02 | 3.316E-02 |
| 159.0 | 4.198E-02 | 3.867E-02 | 3.735E-02 | 3.709E-02 | 3.682E-02 |
| 160.0 | 4.548E-02 | 4.204E-02 | 4.082E-02 | 3.955E-02 | 3.915E-02 |
| 161.0 | 4.277E-02 | 4.387E-02 | 4.329E-02 | 3.977E-02 | 3.942E-02 |
| 162.0 | 4.063E-02 | 4.329E-02 | 4.336E-02 | 4.065E-02 | 4.038E-02 |
| 163.0 | 4.228E-02 | 4.295E-02 | 4.299E-02 | 4.381E-02 | 4.385E-02 |
| 164.0 | 4.248E-02 | 4.065E-02 | 4.110E-02 | 4.359E-02 | 4.354E-02 |
| 165.0 | 4.179E-02 | 4.111E-02 | 4.130E-02 | 4.210E-02 | 4.229E-02 |
| 166.0 | 4.072E-02 | 4.092E-02 | 4.047E-02 | 4.052E-02 | 4.046E-02 |
| 167.0 | 4.251E-02 | 4.237E-02 | 4.237E-02 | 4.188E-02 | 4.192E-02 |
| 168.0 | 4.453E-02 | 4.367E-02 | 4.395E-02 | 4.431E-02 | 4.401E-02 |
| 169.0 | 4.528E-02 | 4.485E-02 | 4.467E-02 | 4.581E-02 | 4.587E-02 |
| 170.0 | 4.688E-02 | 4.541E-02 | 4.542E-02 | 4.664E-02 | [illegible] |
| 171.0 | 4.760E-02 | 4.723E-02 | 4.698E-02 | 4.830E-02 | 4.862E-02 |
| 172.0 | 5.069E-02 | 5.109E-02 | 5.085E-02 | 5.072E-02 | 5.051E-02 |
| 173.0 | 5.443E-02 | 5.355E-02 | 5.387E-02 | [illegible] | 5.410E-02 |
| 174.0 | 5.872E-02 | 5.854E-02 | 5.789E-02 | 5.820E-02 | 5.769E-02 |
| 175.0 | 6.639E-02 | 6.279E-02 | 6.298E-02 | 6.446E-02 | 6.478E-02 |
| 176.0 | 7.196E-02 | 6.831E-02 | 6.875E-02 | 6.989E-02 | 6.911E-02 |
| 177.0 | 7.945E-02 | 7.557E-02 | 7.227E-02 | 7.459E-02 | 7.498E-02 |
| 178.0 | 8.903E-02 | 8.079E-02 | 7.989E-02 | 7.293E-02 | 6.967E-02 |
| 179.0 | 9.774E-02 | 6.026E-02 | 5.249E-02 | 4.763E-02 | 4.700E-02 |
| 180.0 | 5.137E-02 | 4.551E-02 | 4.536E-02 | 4.647E-02 | 4.683E-02 |

TABLE III-J. NORMALIZED VOLUME SCATTERING FUNCTION : $\nu$ = 3.5
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 4.585E 01 | 2.597E 01 | 2.115E 01 | 1.559E 01 | 1.457E 01 |
| 1.0 | 1.563E 01 | 1.476E 01 | 1.378E 01 | 1.180E 01 | 1.133E 01 |
| 2.0 | 6.273E 00 | 6.261E 00 | 6.242E 00 | 6.252E 00 | 6.257E 00 |
| 3.0 | 3.754E 00 | 3.816E 00 | 3.833E 00 | 3.760E 00 | 3.745E 00 |
| 4.0 | 2.644E 00 | 2.705E 00 | 2.712E 00 | 2.677E 00 | 2.681E 00 |
| 5.0 | 2.023E 00 | 2.081E 00 | 2.089E 00 | 2.061E 00 | 2.065E 00 |
| 6.0 | 1.637E 00 | 1.675E 00 | 1.679E 00 | 1.670E 00 | 1.674E 00 |
| 7.0 | 1.368E 00 | 1.386E 00 | 1.394E 00 | 1.391E 00 | 1.391E 00 |
| 8.0 | 1.168E 00 | 1.175E 00 | 1.180E 00 | 1.189E 00 | 1.192E 00 |
| 9.0 | 1.028E 00 | 1.023E 00 | 1.027E 00 | 1.051E 00 | 1.053E 00 |
| 10.0 | 9.204E-01 | 9.094E-01 | 9.132E-01 | 9.364E-01 | 9.375E-01 |
| 11.0 | 8.437E-01 | 8.223E-01 | 8.250E-01 | 8.550E-01 | 8.571E-01 |
| 12.0 | 7.921E-01 | 7.776E-01 | 7.824E-01 | 8.123E-01 | 8.140E-01 |
| 13.0 | 7.551E-01 | 7.401E-01 | 7.413E-01 | 7.635E-01 | 7.637E-01 |
| 14.0 | 6.685E-01 | 6.604E-01 | 6.640E-01 | 6.836E-01 | 6.852E-01 |
| 15.0 | 6.025E-01 | 6.015E-01 | 6.023E-01 | 6.107E-01 | 6.117E-01 |
| 16.0 | 5.538E-01 | 5.540E-01 | 5.573E-01 | 5.627E-01 | 5.632E-01 |
| 17.0 | 5.178E-01 | 5.186E-01 | 5.195E-01 | 5.248E-01 | 5.261E-01 |
| 18.0 | 4.888E-01 | 4.863E-01 | 4.886E-01 | 4.955E-01 | 4.960E-01 |
| 19.0 | 4.642E-01 | 4.621E-01 | 4.628E-01 | 4.713E-01 | 4.717E-01 |
| 20.0 | 4.403E-01 | 4.375E-01 | 4.392E-01 | 4.463E-01 | 4.472E-01 |
| 22.5 | 3.832E-01 | 3.778E-01 | 3.790E-01 | 3.878E-01 | 3.886E-01 |
| 25.0 | 3.276E-01 | 3.254E-01 | 3.260E-01 | 3.324E-01 | 3.331E-01 |
| 27.5 | 2.842E-01 | 2.850E-01 | 2.856E-01 | 2.875E-01 | 2.879E-01 |
| 30.0 | 2.531E-01 | 2.523E-01 | 2.530E-01 | 2.552E-01 | 2.555E-01 |
| 32.5 | 2.213E-01 | 2.205E-01 | 2.210E-01 | 2.233E-01 | 2.236E-01 |
| 35.0 | 1.899E-01 | 1.928E-01 | 1.931E-01 | 1.912E-01 | 1.914E-01 |
| 37.5 | 1.673E-01 | 1.702E-01 | 1.705E-01 | 1.684E-01 | 1.685E-01 |
| 40.0 | 1.496E-01 | 1.509E-01 | 1.513E-01 | 1.506E-01 | 1.508E-01 |
| 42.5 | 1.294E-01 | 1.337E-01 | 1.341E-01 | 1.305E-01 | 1.306E-01 |
| 45.0 | 1.143E-01 | 1.177E-01 | 1.179E-01 | 1.155E-01 | 1.156E-01 |
| 47.5 | 1.033E-01 | 1.037E-01 | 1.040E-01 | 1.043E-01 | 1.044E-01 |
| 50.0 | 9.066E-02 | 9.320E-02 | 9.339E-02 | 9.180E-02 | 9.183E-02 |
| 52.5 | 8.004E-02 | 8.192E-02 | 8.209E-02 | 8.084E-02 | 8.086E-02 |
| 55.0 | 7.131E-02 | 7.211E-02 | 7.219E-02 | 7.188E-02 | 7.194E-02 |
| 57.5 | 6.475E-02 | 6.592E-02 | 6.620E-02 | 6.605E-02 | 6.616E-02 |
| 60.0 | 5.623E-02 | 5.758E-02 | 5.764E-02 | 5.689E-02 | 5.697E-02 |
| 62.5 | 5.130E-02 | 5.219E-02 | 5.234E-02 | 5.190E-02 | 5.197E-02 |
| 65.0 | 4.622E-02 | 4.671E-02 | 4.680E-02 | 4.696E-02 | 4.704E-02 |
| 67.5 | 4.121E-02 | 4.183E-02 | 4.199E-02 | 4.199E-02 | 4.204E-02 |
| 70.0 | 3.693E-02 | 3.796E-02 | 3.811E-02 | 3.766E-02 | 3.767E-02 |
| 72.5 | 3.354E-02 | 3.396E-02 | 3.407E-02 | 3.428E-02 | 3.432E-02 |
| 75.0 | 3.083E-02 | 3.121E-02 | 3.132E-02 | 3.147E-02 | 3.153E-02 |
| 77.5 | 2.730E-02 | 2.813E-02 | 2.826E-02 | 2.803E-02 | 2.808E-02 |
| 80.0 | 2.526E-02 | 2.573E-02 | 2.581E-02 | 2.592E-02 | 2.596E-02 |
| 82.5 | 2.352E-02 | 2.384E-02 | 2.398E-02 | 2.414E-02 | 2.419E-02 |
| 85.0 | 2.158E-02 | 2.184E-02 | 2.195E-02 | 2.218E-02 | 2.222E-02 |
| 87.5 | 1.969E-02 | 2.001E-02 | 2.007E-02 | 2.017E-02 | 2.020E-02 |
| 90.0 | 1.776E-02 | 1.800E-02 | 1.807E-02 | 1.826E-02 | 1.828E-02 |
| 92.5 | 1.632E-02 | 1.673E-02 | 1.680E-02 | 1.681E-02 | 1.683E-02 |

TABLE III-J. NORMALIZED VOLUME SCATTERING FUNCTION: $\nu$ = 3.5
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.527E-02 | 1.562E-02 | 1.569E-02 | 1.580E-02 | 1.583E-02 |
| 97.5 | 1.483E-02 | 1.515E-02 | 1.524E-02 | 1.534E-02 | 1.538E-02 |
| 100.0 | 1.385E-02 | 1.420E-02 | 1.428E-02 | 1.438E-02 | 1.441E-02 |
| 102.5 | 1.305E-02 | 1.338E-02 | 1.346E-02 | 1.357E-02 | 1.360E-02 |
| 105.0 | 1.238E-02 | 1.268E-02 | 1.276E-02 | 1.288E-02 | 1.293E-02 |
| 107.5 | 1.157E-02 | 1.171E-02 | 1.177E-02 | 1.202E-02 | 1.204E-02 |
| 110.0 | 1.098E-02 | 1.123E-02 | 1.131E-02 | 1.146E-02 | 1.149E-02 |
| 112.5 | 1.082E-02 | 1.098E-02 | 1.103E-02 | 1.129E-02 | 1.131E-02 |
| 115.0 | 1.069E-02 | 1.080E-02 | 1.086E-02 | 1.114E-02 | 1.117E-02 |
| 117.5 | 1.042E-02 | 1.069E-02 | 1.075E-02 | 1.089E-02 | 1.091E-02 |
| 120.0 | 1.050E-02 | 1.067E-02 | 1.074E-02 | 1.095E-02 | 1.098E-02 |
| 122.5 | 1.053E-02 | 1.071E-02 | 1.077E-02 | 1.102E-02 | 1.105E-02 |
| 125.0 | 1.045E-02 | 1.071E-02 | 1.077E-02 | 1.095E-02 | 1.097E-02 |
| 127.5 | 1.064E-02 | 1.076E-02 | 1.082E-02 | 1.114E-02 | 1.117E-02 |
| 130.0 | 1.080E-02 | 1.084E-02 | 1.091E-02 | 1.132E-02 | 1.135E-02 |
| 132.5 | 1.106E-02 | 1.109E-02 | 1.115E-02 | 1.157E-02 | 1.159E-02 |
| 135.0 | 1.134E-02 | 1.156E-02 | 1.163E-02 | 1.189E-02 | 1.192E-02 |
| 137.5 | 1.172E-02 | 1.209E-02 | 1.217E-02 | 1.227E-02 | 1.230E-02 |
| 140.0 | 1.244E-02 | 1.281E-02 | 1.289E-02 | 1.303E-02 | 1.306E-02 |
| 142.5 | 1.325E-02 | 1.362E-02 | 1.371E-02 | 1.387E-02 | 1.390E-02 |
| 145.0 | 1.402E-02 | 1.437E-02 | 1.445E-02 | 1.465E-02 | 1.468E-02 |
| 147.5 | 1.554E-02 | 1.579E-02 | 1.588E-02 | 1.622E-02 | 1.626E-02 |
| 150.0 | 1.741E-02 | 1.751E-02 | 1.762E-02 | 1.818E-02 | 1.823E-02 |
| 152.5 | 1.945E-02 | 1.965E-02 | 1.975E-02 | 2.020E-02 | 2.024E-02 |
| 155.0 | 2.320E-02 | 2.315E-02 | 2.324E-02 | 2.389E-02 | 2.390E-02 |
| 156.0 | 2.498E-02 | 2.486E-02 | 2.483E-02 | 2.528E-02 | 2.529E-02 |
| 157.0 | 2.678E-02 | 2.650E-02 | 2.643E-02 | 2.658E-02 | 2.654E-02 |
| 158.0 | 2.926E-02 | 2.848E-02 | 2.830E-02 | 2.833E-02 | 2.831E-02 |
| 159.0 | 3.144E-02 | 3.040E-02 | 3.001E-02 | 3.017E-02 | 3.007E-02 |
| 160.0 | 3.303E-02 | 3.208E-02 | 3.171E-02 | 3.137E-02 | 3.124E-02 |
| 161.0 | 3.266E-02 | 3.332E-02 | 3.310E-02 | 3.173E-02 | 3.161E-02 |
| 162.0 | 3.264E-02 | 3.364E-02 | 3.358E-02 | 3.245E-02 | 3.235E-02 |
| 163.0 | 3.386E-02 | 3.384E-02 | 3.378E-02 | 3.405E-02 | 3.403E-02 |
| 164.0 | 3.423E-02 | 3.347E-02 | 3.353E-02 | 3.442E-02 | 3.438E-02 |
| 165.0 | 3.413E-02 | 3.378E-02 | 3.377E-02 | 3.412E-02 | 3.415E-02 |
| 166.0 | 3.387E-02 | 3.390E-02 | 3.374E-02 | 3.374E-02 | 3.371E-02 |
| 167.0 | 3.476E-02 | 3.468E-02 | 3.463E-02 | 3.449E-02 | 3.448E-02 |
| 168.0 | 3.593E-02 | 3.552E-02 | 3.554E-02 | 3.573E-02 | 3.562E-02 |
| 169.0 | 3.659E-02 | 3.620E-02 | 3.609E-02 | 3.659E-02 | 3.658E-02 |
| 170.0 | 3.745E-02 | 3.670E-02 | 3.665E-02 | 3.722E-02 | 3.714E-02 |
| 171.0 | 3.820E-02 | 3.783E-02 | 3.770E-02 | 3.822E-02 | 3.828E-02 |
| 172.0 | 3.977E-02 | 3.981E-02 | 3.967E-02 | 3.954E-02 | 3.945E-02 |
| 173.0 | 4.162E-02 | 4.153E-02 | 4.153E-02 | 4.120E-02 | 4.123E-02 |
| 174.0 | 4.393E-02 | 4.395E-02 | 4.367E-02 | 4.343E-02 | 4.324E-02 |
| 175.0 | 4.731E-02 | 4.617E-02 | 4.609E-02 | 4.633E-02 | 4.637E-02 |
| 176.0 | 4.985E-02 | 4.856E-02 | 4.854E-02 | 4.872E-02 | 4.843E-02 |
| 177.0 | 5.214E-02 | 5.078E-02 | 4.977E-02 | 5.026E-02 | 5.029E-02 |
| 178.0 | 5.401E-02 | 5.164E-02 | 5.120E-02 | 4.905E-02 | 4.805E-02 |
| 179.0 | 5.379E-02 | 4.493E-02 | [illegible].289E-02 | 4.151E-02 | 4.131E-02 |
| 180.0 | 4.270E-02 | 4.138E-02 | 4.131E-02 | 4.158E-02 | 4.167E-02 |

TABLE III-K. NORMALIZED VOLUME SCATTERING FUNCTION : ν = 4.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 0. | 1.088E 01 | 7.488E 00 | 6.570E 00 | 5.416E 00 | 5.189E 00 |
| 1.0 | 5.285E 00 | 5.066E 00 | 4.871E 00 | 4.448E 00 | 4.342E 00 |
| 2.0 | 2.993E 00 | 2.962E 00 | 2.955E 00 | 2.946E 00 | 2.945E 00 |
| 3.0 | 2.174E 00 | 2.170E 00 | 2.171E 00 | 2.148E 00 | 2.143E 00 |
| 4.0 | 1.743E 00 | 1.743E 00 | 1.743E 00 | 1.730E 00 | 1.730E 00 |
| 5.0 | 1.470E 00 | 1.470E 00 | 1.470E 00 | 1.462E 00 | 1.462E 00 |
| 6.0 | 1.279E 00 | 1.274E 00 | 1.274E 00 | 1.273E 00 | 1.273E 00 |
| 7.0 | 1.134E 00 | 1.124E 00 | 1.125E 00 | 1.128E 00 | 1.128E 00 |
| 8.0 | 1.020E 00 | 1.007E 00 | 1.007E 00 | 1.016E 00 | 1.016E 00 |
| 9.0 | 9.323E-01 | 9.148E-01 | 9.154E-01 | 9.293E-01 | 9.295E-01 |
| 10.0 | 8.606E-01 | 8.411E-01 | 8.417E-01 | 8.569E-01 | 8.571E-01 |
| 11.0 | 8.029E-01 | 7.813E-01 | 7.817E-01 | 7.991E-01 | 7.995E-01 |
| 12.0 | 7.563E-01 | 7.366E-01 | 7.374E-01 | 7.544E-01 | 7.547E-01 |
| 13.0 | 7.135E-01 | 6.954E-01 | 6.956E-01 | 7.099E-01 | 7.099E-01 |
| 14.0 | 6.605E-01 | 6.460E-01 | 6.466E-01 | 6.588E-01 | 6.591E-01 |
| 15.0 | 6.137E-01 | 6.024E-01 | 6.026E-01 | 6.111E-01 | 6.113E-01 |
| 16.0 | 5.744E-01 | 5.647E-01 | 5.654E-01 | 5.723E-01 | 5.725E-01 |
| 17.0 | 5.415E-01 | 5.324E-01 | 5.326E-01 | 5.395E-01 | 5.398E-01 |
| 18.0 | 5.130E-01 | 5.032E-01 | 5.037E-01 | 5.111E-01 | 5.112E-01 |
| 19.0 | 4.872E-01 | 4.777E-01 | 4.778E-01 | 4.856E-01 | 4.857E-01 |
| 20.0 | 4.628E-01 | 4.534E-01 | 4.538E-01 | 4.612E-01 | 4.614E-01 |
| 22.5 | 4.059E-01 | 3.966E-01 | 3.969E-01 | 4.045E-01 | 4.047E-01 |
| 25.0 | 3.536E-01 | 3.469E-01 | 3.470E-01 | 3.527E-01 | 3.529E-01 |
| 27.5 | 3.094E-01 | 3.058E-01 | 3.060E-01 | 3.085E-01 | 3.086E-01 |
| 30.0 | 2.735E-01 | 2.713E-01 | 2.715E-01 | 2.727E-01 | 2.727E-01 |
| 32.5 | 2.404E-01 | 2.398E-01 | 2.400E-01 | 2.398E-01 | 2.399E-01 |
| 35.0 | 2.095E-01 | 2.122E-01 | 2.123E-01 | 2.090E-01 | 2.091E-01 |
| 37.5 | 1.850E-01 | 1.881E-01 | 1.882E-01 | 1.847E-01 | 1.847E-01 |
| 40.0 | 1.646E-01 | 1.669E-01 | 1.670E-01 | 1.644E-01 | 1.644E-01 |
| 42.5 | 1.447E-01 | 1.483E-01 | 1.483E-01 | 1.446E-01 | 1.447E-01 |
| 45.0 | 1.284E-01 | 1.313E-01 | 1.314E-01 | 1.285E-01 | 1.285E-01 |
| 47.5 | 1.151E-01 | 1.165E-01 | 1.166E-01 | 1.152E-01 | 1.152E-01 |
| 50.0 | 1.022E-01 | 1.042E-01 | 1.042E-01 | 1.024E-01 | 1.024E-01 |
| 52.5 | 9.086E-02 | 9.252E-02 | 9.257E-02 | 9.104E-02 | 9.105E-02 |
| 55.0 | 8.138E-02 | 8.239E-02 | 8.242E-02 | 8.156E-02 | 8.158E-02 |
| 57.5 | 7.334E-02 | 7.439E-02 | 7.445E-02 | 7.370E-02 | 7.373E-02 |
| 60.0 | 6.502E-02 | 6.613E-02 | 6.615E-02 | 6.531E-02 | 6.534E-02 |
| 62.5 | 5.889E-02 | 5.971E-02 | 5.974E-02 | 5.918E-02 | 5.920E-02 |
| 65.0 | 5.318E-02 | 5.372E-02 | 5.375E-02 | 5.353E-02 | 5.355E-02 |
| 67.5 | 4.796E-02 | 4.854E-02 | 4.858E-02 | 4.834E-02 | 4.835E-02 |
| 70.0 | 4.333E-02 | 4.406E-02 | 4.410E-02 | 4.372E-02 | 4.372E-02 |
| 72.5 | 3.940E-02 | 3.986E-02 | 3.989E-02 | 3.981E-02 | 3.982E-02 |
| 75.0 | 3.607E-02 | 3.650E-02 | 3.653E-02 | 3.647E-02 | 3.648E-02 |
| 77.5 | 3.269E-02 | 3.328E-02 | 3.331E-02 | 3.312E-02 | 3.313E-02 |
| 80.0 | 3.009E-02 | 3.052E-02 | 3.054E-02 | 3.051E-02 | 3.052E-02 |
| 82.5 | 2.784E-02 | 2.821E-02 | 2.824E-02 | 2.826E-02 | 2.828E-02 |
| 85.0 | 2.562E-02 | 2.601E-02 | 2.603E-02 | 2.605E-02 | 2.606E-02 |
| 87.5 | 2.352E-02 | 2.390E-02 | 2.392E-02 | 2.394E-02 | 2.394E-02 |
| 90.0 | 2.160E-02 | 2.193E-02 | 2.195E-02 | 2.203E-02 | 2.204E-02 |
| 92.5 | 2.006E-02 | 2.047E-02 | 2.048E-02 | 2.049E-02 | 2.050E-02 |

TABLE III-K. NORMALIZED VOLUME SCATTERING FUNCTION: $\nu$ = 4.0
INDEX OF REFRACTION = 1.50

| SCATTERING ANGLE (deg) | WAVELENGTH (MICRONS) .30 | .45 | .50 | .65 | .70 |
|---|---|---|---|---|---|
| 95.0 | 1.892E-02 | 1.929E-02 | 1.931E-02 | 1.937E-02 | 1.938E-02 |
| 97.5 | 1.811E-02 | 1.848E-02 | 1.850E-02 | 1.857E-02 | 1.858E-02 |
| 100.0 | 1.713E-02 | 1.752E-02 | 1.754E-02 | 1.760E-02 | 1.761E-02 |
| 102.5 | 1.625E-02 | 1.664E-02 | 1.665E-02 | 1.674E-02 | 1.675E-02 |
| 105.0 | 1.546E-02 | 1.584E-02 | 1.586E-02 | 1.595E-02 | 1.596E-02 |
| 107.5 | 1.466E-02 | 1.500E-02 | 1.502E-02 | 1.516E-02 | 1.516E-02 |
| 110.0 | 1.406E-02 | 1.447E-02 | 1.448E-02 | 1.458E-02 | 1.459E-02 |
| 112.5 | 1.375E-02 | 1.414E-02 | 1.415E-02 | 1.428E-02 | 1.429E-02 |
| 115.0 | 1.354E-02 | 1.392E-02 | 1.393E-02 | 1.408E-02 | 1.409E-02 |
| 117.5 | 1.334E-02 | 1.381E-02 | 1.382E-02 | 1.390E-02 | 1.391E-02 |
| 120.0 | 1.334E-02 | 1.378E-02 | 1.380E-02 | 1.392E-02 | 1.392E-02 |
| 122.5 | 1.337E-02 | 1.379E-02 | 1.381E-02 | 1.396E-02 | 1.397E-02 |
| 125.0 | 1.336E-02 | 1.382E-02 | 1.383E-02 | 1.398E-02 | 1.398E-02 |
| 127.5 | 1.350E-02 | 1.390E-02 | 1.391E-02 | 1.413E-02 | 1.414E-02 |
| 130.0 | 1.365E-02 | 1.403E-02 | 1.404E-02 | 1.430E-02 | 1.431E-02 |
| 132.5 | 1.387E-02 | 1.429E-02 | 1.431E-02 | 1.454E-02 | 1.454E-02 |
| 135.0 | 1.414E-02 | 1.471E-02 | 1.472E-02 | 1.482E-02 | 1.483E-02 |
| 137.5 | 1.446E-02 | 1.520E-02 | 1.522E-02 | 1.517E-02 | 1.518E-02 |
| 140.0 | 1.504E-02 | 1.583E-02 | 1.585E-02 | 1.577E-02 | 1.578E-02 |
| 142.5 | 1.573E-02 | 1.652E-02 | 1.654E-02 | 1.647E-02 | 1.648E-02 |
| 145.0 | 1.646E-02 | 1.722E-02 | 1.724E-02 | 1.721E-02 | 1.722E-02 |
| 147.5 | 1.760E-02 | 1.824E-02 | 1.826E-02 | 1.836E-02 | 1.837E-02 |
| 150.0 | 1.891E-02 | 1.947E-02 | 1.949E-02 | 1.970E-02 | 1.971E-02 |
| 152.5 | 2.026E-02 | 2.087E-02 | 2.089E-02 | 2.104E-02 | 2.105E-02 |
| 155.0 | 2.225E-02 | 2.277E-02 | 2.278E-02 | 2.300E-02 | 2.301E-02 |
| 156.0 | 2.308E-02 | 2.360E-02 | 2.359E-02 | 2.375E-02 | 2.375E-02 |
| 157.0 | 2.387E-02 | 2.439E-02 | 2.437E-02 | 2.445E-02 | 2.444E-02 |
| 158.0 | 2.480E-02 | 2.523E-02 | 2.520E-02 | 2.524E-02 | 2.524E-02 |
| 159.0 | 2.565E-02 | 2.606E-02 | 2.598E-02 | 2.603E-02 | 2.600E-02 |
| 160.0 | 2.629E-02 | 2.682E-02 | 2.674E-02 | 2.658E-02 | 2.655E-02 |
| 161.0 | 2.646E-02 | 2.746E-02 | 2.741E-02 | 2.688E-02 | 2.685E-02 |
| 162.0 | 2.675E-02 | 2.782E-02 | 2.781E-02 | 2.730E-02 | 2.728E-02 |
| 163.0 | 2.737E-02 | 2.809E-02 | 2.807E-02 | 2.799E-02 | 2.798E-02 |
| 164.0 | 2.769E-02 | 2.822E-02 | 2.822E-02 | 2.833E-02 | 2.831E-02 |
| 165.0 | 2.781E-02 | 2.847E-02 | 2.846E-02 | 2.841E-02 | 2.841E-02 |
| 166.0 | 2.789E-02 | 2.869E-02 | 2.865E-02 | 2.847E-02 | 2.845E-02 |
| 167.0 | 2.833E-02 | 2.912E-02 | 2.910E-02 | 2.888E-02 | 2.887E-02 |
| 168.0 | 2.892E-02 | 2.961E-02 | 2.961E-02 | 2.948E-02 | 2.945E-02 |
| 169.0 | 2.939E-02 | 3.006E-02 | 3.003E-02 | 2.998E-02 | 2.997E-02 |
| 170.0 | 2.990E-02 | 3.050E-02 | 3.049E-02 | 3.045E-02 | 3.043E-02 |
| 171.0 | 3.047E-02 | 3.121E-02 | 3.117E-02 | 3.107E-02 | 3.107E-02 |
| 172.0 | 3.129E-02 | 3.222E-02 | 3.218E-02 | 3.182E-02 | 3.179E-02 |
| 173.0 | 3.224E-02 | 3.326E-02 | 3.325E-02 | 3.273E-02 | 3.273E-02 |
| 174.0 | 3.342E-02 | 3.448E-02 | 3.441E-02 | 3.388E-02 | 3.383E-02 |
| 175.0 | 3.487E-02 | 3.565E-02 | 3.562E-02 | 3.522E-02 | 3.522E-02 |
| 176.0 | 3.607E-02 | 3.679E-02 | 3.677E-02 | 3.637E-02 | 3.630E-02 |
| 177.0 | 3.696E-02 | 3.767E-02 | 3.746E-02 | 3.713E-02 | 3.713E-02 |
| 178.0 | 3.745E-02 | 3.802E-02 | 3.792E-02 | 3.702E-02 | 3.680E-02 |
| 179.0 | 3.719E-02 | 3.673E-02 | 3.634E-02 | 3.561E-02 | 3.556E-02 |
| 180.0 | 3.548E-02 | 3.627E-02 | 3.624E-02 | 3.586E-02 | 3.588E-02 |

Table IV. Average Cosine of the Scattering Angle for Various Aerosol Particle Size Distributions

$\overline{\cos\theta}$

| Index of Refraction | Aerosol Model | Wave Length ($\mu$) 0.30 | 0.45 | 0.50 | 0.65 | 0.70 |
|---|---|---|---|---|---|---|
| 1.5 | Cloud | 0.7374 | 0.8168 | 0.8071 | 0.8039 | 0.8020 |
| 1.5 | Haze C | 0.6751 | 0.6738 | 0.6689 | 0.6530 | 0.6456 |
| 1.5 | Haze M | 0.7308 | 0.7084 | 0.7036 | 0.6924 | 0.6926 |
| 1.5 | $\nu$ = 2.0 | 0.7060 | 0.7934 | 0.7967 | 0.7844 | 0.7828 |
| 1.5 | $\nu$ = 2.5 | 0.7240 | 0.7672 | 0.7672 | 0.7570 | 0.7546 |
| 1.5 | $\nu$ = 3.0 | 0.7147 | 0.7278 | 0.7266 | 0.7206 | 0.7193 |
| 1.5 | $\nu$ = 3.5 | 0.6848 | 0.6850 | 0.6841 | 0.6824 | 0.6820 |
| 1.5 | $\nu$ = 4.0 | 0.6490 | 0.6430 | 0.6429 | 0.6433 | 0.6433 |
| 1.33 | Cloud | 0.8066 | 0.8908 | 0.8902 | 0.8705 | 0.8575 |
| 1.33 | Haze C | 0.7677 | 0.7692 | 0.7653 | 0.7499 | 0.7440 |
| 1.33 | Haze M | 0.8054 | 0.7963 | 0.7958 | 0.8003 | 0.8002 |

# IV. UTILIZATION INSTRUCTIONS - RRA-42

## 4.1 Description

RRA-42 is designed to calculate the microscopic scattering quantities discussed in Section 2.1, $i_1$, $i_2$, $i_3$, $i_4$, $\frac{i_1 + i_2}{2}$, the extinction efficiency, the scattering efficiency, and the polarization of the scattered light. Available also as optional printouts are the values of $a_n$, $b_n$, $S_1$ and $S_2$ used in the calculations.

The basic input variables are the index of refraction and the size parameters of the spheres involved in the calculations. There are eleven other input variables necessary for controlling the operational procedure. The variable, NPROB, allows calculations to be performed for any number of different values of the refractive index or angular increments without requiring a reloading of the program deck. The angular dependent functions are calculated at the angles defined by the relation

$$\theta = 0°(\mathrm{DTHET1})\mathrm{CHANG1}(\mathrm{DTHET2})\mathrm{CHANG2}(\mathrm{DTHET3})180° \ . \qquad (38)$$

The number of degrees in the range for each angular increment must be an exact multiple of the angular increment. There are two variables (DECIDE and OPTION) for the control of the printout involving the $a_n$, $b_n$, $S_1(\theta)$, and $S_2(\theta)$.

The infinite series in n for the values calculated are terminated either when $n = 1.2\, x + 9$, where x is the size parameter, or when the condition

$$\frac{|a_n|^2 + |b_n|^2}{n} < 10^{-P} \qquad (39)$$

is satisfied, where P is an input parameter.

The following list of input variables describes their function and input format. The numbers in circles refer to cards or card sections as shown in the sample input data.

## 4.2 Input Variables

Table V lists the problem input data for RRA-42. The formats to be used in making up a problem deck are also given in Table V.

Table V. Problem Data Deck for RRA-42

| Variable | Definition | Format | Card No. |
|---|---|---|---|
| NPROB | Number of problems. Each problem corresponds to a given refractive index or set of angular increments. A complete set of size parameters may be run under one problem. For each problem, a complete set of the following variables must be input. | I5 | 1 |
| PM | Index of refraction. Input two numbers for each index, the real and imaginary part. If the index is real, input zero for imaginary part. | 2E18.8 | 2 |
| DTHET1, DTHET2, DTHET3 | Angular increments in degrees as expressed in Equation 38. If the same increment is to be used from 0° to 180°, this number must be input for each of these three variables. | 3F5.2 | 2 |
| CHANG1, CHANG2 | Angle in degrees at which increments are to be changed, as shown in Equation 38. | 2F5.2 | 2 |
| LPROBN | Number designation for a particular problem. | I4 | 2 |
| DECIDE | Decision for printing out $a_n$, $b_n$, $\|a_n\|^2$, and $\|b_n\|^2$ as a function of n. Input zero to print out; any other number will suppress the printout. | 2E18.8 | 3 |
| OPTION | Decision for printing out $S_1$ and $S_2$ as a function of θ. Input zero to printout; any other number will suppress the printout. | 2E18.8 | 3 |
| NEXES | Number of size parameters to be used within any one problem | 2I4 | 4 |

Table V. (continued)

| Variable | Definition | Format | Card No. |
|---|---|---|---|
| IPOWER | Corresponds to P in test relation $\|a_n\|^2 + \|b_n\|^2 < 10^{-P}$. A value of 14 is recommended. | ↓ | ↓ |
| X | Size parameter, one value to a card. If NEXES=10, input 10 cards, each containing one size parameter. If output is to be used in RRA-45, input x's in order of increasing size. | E18.8 | 5 |

4.3 Input Instructions

1. Variables PM(2 values), DTHET1, DTHET2, DTHET3, CHANG1, CHANG2 and LPROBN are input on one card.
2. DECIDE and OPTION are input on one card.
3. NEXES and IPOWER are input on one card.
4. Variables are input in the order they appear in Table V. The data deck for one problem will consist of four cards plus NEXES additional cards.
5. A deck containing variables PM through all x's must be input for each problem, one deck immediately following another.

In addition to the printed output, a tape may be generated containing the size parameters used, the extinction and scattering cross sections, and the function $\frac{i_1 + i_2}{2}$ for each scattering angle. This tape may be converted to punched cards if desired; however, the data is written on the tape in the format required by the integration procedure, RRA-45. Therefore, this output tape may be used as an input library tape for RRA-45, eliminating the need for converting this data to large numbers of punched cards. If the tape is to be used as a library tape, the size parameters must be calculated in the order of increasing size.

The following table gives the file names of the input-output files.

| Input-Output Files | File Name |
|---|---|
| 1. Program deck | CARD |
| 2. Input data | CARD |
| 3. Printed output | PRINT |
| 4. Library tape or punched putput for RRA-45 | PUNCH |

When using the B-5500 system, for which these programs are designed, the input-output files may be declared by the computer operator as any input-output hardware device desired. Thus, for example, the program deck and input data may be input from magnetic tape, the printed output may be stored on a tape, and the punched output or library tape may be punched directly, if so desired.

4.4 Sample Problem

Listings of the problem input data and corresponding printed output for a sample problem are given in Tables VI and VII, respectively. Table VIII gives a listing of the punched cards produced.

The quantities I1, I2, I3, and I4 as given in Table VII correspond to the quantities defined in Equations 14 - 17. IAVG = $\frac{i_1 + i_2}{2}$. The POLARIZATION = $\frac{i_1 - i_2}{i_1 + i_2}$ . The extinction and scattering efficiencies are defined in Equations 12 and 13.

## TABLE VI. RRA-42 SAMPLE PROBLEM INPUT DATA

```
   1
        1.423E&00          -1.280E-02 2.00 5.00 2.50 20.0145.0  11
         1.00E&00           1.00E&00
01   14
         1.84E&01
```

TABLE VII. RRA-42 SAMPLE PROBLEM PRINTED OUTPUT DATA

RADIATION RESEARCH ASSOCIATES , FORT WORTH , TEXAS , PROCEDURE RRA-42

ANALYSIS OF MIE SCATTERING - PROBLEM NUMBER 11

INDEX OF REFRACTION = ( 1.423000 , 0.012800 )

SIZE PARAMETER = 1.84000E+01 OTHET1 = 2.00 OTHET2 = 5.00 OTHET3 = 2.50

| SCATTERING ANGLE | I1 | I2 | I3 | I4 | IAVG | POLARIZATION |
|---|---|---|---|---|---|---|
| 0.00 | 3.6641E+04 | 3.6641E+04 | 3.6641E+04 | 0.0000E+00 | 3.6641E+04 | 0.0000E+00 |
| 2.00 | 3.2602E+04 | 3.2622E+04 | 3.2612E+04 | -6.7363E+01 | 3.2612E+04 | -3.0585E-04 |
| 4.00 | 2.2715E+04 | 2.2765E+04 | 2.2739E+04 | -2.6366E+02 | 2.2740E+04 | -1.0969E-03 |
| 6.00 | 1.1949E+04 | 1.1983E+04 | 1.1961E+04 | -3.6063E+02 | 1.1966E+04 | -1.4297E-03 |
| 8.00 | 4.4411E+03 | 4.3989E+03 | 4.4100E+03 | -2.9685E+02 | 4.4200E+03 | 4.7754E-03 |
| 10.00 | 1.1753E+03 | 1.0475E+03 | 1.1001E+03 | -1.4455E+02 | 1.1114E+03 | 5.7461E-02 |
| 12.00 | 5.1755E+02 | 3.6753E+02 | 4.3487E+02 | -3.3269E+01 | 4.4254E+02 | 1.6949E-01 |
| 14.00 | 4.5391E+02 | 3.6302E+02 | 4.0576E+02 | -1.1693E+01 | 4.0847E+02 | 1.1125E-01 |
| 16.00 | 1.8745E+02 | 1.7739E+02 | 1.8095E+02 | -2.2540E+01 | 1.8242E+02 | 2.7565E-02 |
| 18.00 | 4.3336E-01 | 1.3212E+01 | 2.3096E+00 | 6.2562E-01 | 6.8226E+00 | -9.3648E-01 |
| 20.00 | 2.0639E+02 | 1.6742E+02 | 1.7983E+02 | 4.7062E+01 | 1.8690E+02 | 1.0424E-01 |
| 25.00 | 5.9752E+02 | 5.4144E+02 | 5.6841E+02 | -2.0655E+01 | 5.6948E+02 | 4.9243E-02 |
| 30.00 | 6.6400E+01 | 1.4206E+02 | 9.3601E+01 | 2.5918E+01 | 1.0423E+02 | -3.6295E-01 |
| 35.00 | 3.6173E+02 | 3.1068E+02 | 3.3522E+02 | 3.2446E+00 | 3.3621E+02 | 7.5908E-02 |
| 40.00 | 2.5042E+01 | 9.9229E+01 | 4.9398E+01 | -6.6884E+00 | 6.2135E+01 | -5.9698E-01 |
| 45.00 | 1.7733E+02 | 1.3929E+02 | 1.5645E+02 | 1.4940E+01 | 1.5831E+02 | 1.2016E-01 |
| 50.00 | 1.9543E+01 | 6.9227E+01 | 3.2105E+01 | -1.7950E+01 | 4.4385E+01 | -5.5969E-01 |
| 55.00 | 9.0441E+01 | 6.4430E+01 | 7.4317E+01 | 1.7439E+01 | 7.7436E+01 | 1.6795E-01 |
| 60.00 | 1.9830E+01 | 4.9483E+01 | 2.4741E+01 | -1.9214E+01 | 3.4657E+01 | -4.2781E-01 |
| 65.00 | 4.4161E+01 | 3.1117E+01 | 3.3553E+01 | 1.5759E+01 | 3.7639E+01 | 1.7327E-01 |
| 70.00 | 2.2043E+01 | 3.4767E+01 | 2.2448E+01 | -1.6201E+01 | 2.8405E+01 | -2.2396E-01 |
| 75.00 | 1.7288E+01 | 1.6981E+01 | 1.2159E+01 | 1.2072E+01 | 1.7134E+01 | 8.9771E-03 |
| 80.00 | 2.5117E+01 | 2.0600E+01 | 2.0000E+01 | -1.0836E+01 | 2.2859E+01 | 9.8803E-02 |
| 85.00 | 5.5430E+00 | 1.2697E+01 | 1.2585E+00 | 8.2944E+00 | 9.1201E+00 | -3.9222E-01 |
| 90.00 | 2.7270E+01 | 8.4677E+00 | 1.4468E+01 | -4.6471E+00 | 1.7869E+01 | 5.2611E-01 |
| 95.00 | 3.0881E+00 | 1.2552E+01 | -4.3063E+00 | 4.4965E+00 | 7.8201E+00 | -6.0510E-01 |
| 100.00 | 2.3772E+01 | 2.0282E+00 | 6.8817E+00 | 9.2597E-01 | 1.2900E+01 | 8.4277E-01 |
| 105.00 | 1.8911E+00 | 1.1282E+01 | -4.6188E+00 | 4.6851E-02 | 6.5865E+00 | -7.1289E-01 |
| 110.00 | 1.2708E+01 | 1.6073E+00 | 1.7097E+00 | 4.1836E+00 | 7.1577E+00 | 7.7545E-01 |
| 115.00 | 1.5706E+00 | 5.1434E+00 | -5.8763E-01 | -2.7808E+00 | 3.3570E+00 | -5.3214E-01 |
| 120.00 | 3.0460E+00 | 5.1528E+00 | -1.0063E+00 | 3.8318E+00 | 4.0994E+00 | -2.5696E-01 |
| 125.00 | 6.1643E+00 | 3.1364E-02 | -5.1757E-03 | -4.3967E-01 | 3.0978E+00 | 9.8988E-01 |
| 130.00 | 4.6957E-01 | 7.4400E+00 | -1.2649E+00 | -1.3761E+00 | 3.9548E+00 | -8.8127E-01 |
| 135.00 | 8.5309E+00 | 3.9653E+00 | -4.4641E+00 | 3.7281E+00 | 6.2481E+00 | 3.6536E-01 |
| 140.00 | 1.1347E+01 | 2.7889E-01 | 1.7659E+00 | 2.1488E-01 | 5.8130E+00 | 9.5202E-01 |
| 145.00 | 2.5124E-01 | 3.2228E+00 | 1.1558E-01 | 8.9237E-01 | 1.7370E+00 | -8.5536E-01 |
| 147.50 | 8.7071E+00 | 9.8801E+00 | -8.5655E-01 | 9.2354E+00 | 9.2936E+00 | -6.3110E-02 |
| 150.00 | 2.1620E+01 | 1.8112E+01 | -3.8074E+00 | 1.9418E+01 | 1.9866E+01 | 8.8295E-02 |
| 152.50 | 2.5449E+01 | 1.6403E+01 | -1.0326E+01 | 1.7630E+01 | 2.0926E+01 | 2.1615E-01 |
| 155.00 | 2.4853E+01 | 5.0337E+00 | -1.0501E+01 | 3.8506E+00 | 1.4943E+01 | 6.6315E-01 |
| 157.50 | 3.2566E+01 | 5.0829E-01 | 2.6569E+00 | -3.0812E+00 | 1.6537E+01 | 9.6926E-01 |
| 160.00 | 3.6332E+01 | 5.8024E+00 | 1.4325E+01 | 2.3701E+00 | 2.1067E+01 | 7.2458E-01 |
| 162.50 | 1.8255E+01 | 5.1875E+00 | 8.8130E+00 | 4.1269E+00 | 1.1721E+01 | 5.5744E-01 |
| 165.00 | 2.9398E+00 | 7.7490E-01 | 1.3855E+00 | 5.9873E-01 | 1.8573E+00 | 5.8279E-01 |
| 167.50 | 2.5571E+01 | 1.1254E+01 | 1.5224E+01 | 7.4844E+00 | 1.8413E+01 | 3.8878E-01 |
| 170.00 | 6.0900E+01 | 2.7549E+01 | 3.6939E+01 | 1.7698E+01 | 4.4224E+01 | 3.7707E-01 |
| 172.50 | 5.7860E+01 | 2.3567E+01 | 3.5530E+01 | 1.0060E+01 | 4.0713E+01 | 4.2115E-01 |
| 175.00 | 2.6091E+01 | 7.6130E+00 | 1.3091E+01 | -5.2217E+00 | 1.6852E+01 | 5.4821E-01 |
| 177.50 | 9.4518E+00 | 5.0614E+00 | -4.5038E+00 | -5.2493E+00 | 7.2566E+00 | 3.0251E-01 |
| 180.00 | 9.0805E+00 | 9.0805E+00 | -9.0805E+00 | -1.0186E-09 | 9.0805E+00 | -1.0256E-10 |

EXTINCTION EFFICIENCY = 2.261057E+00

SCATTERING EFFICIENCY = 1.599672E+00

TABLE VIII. RRA-42 SAMPLE PROBLEM PUNCHED OUTPUT

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.840000E+01 | 2.261057E+00 | 1.599672E+00 | | 11 | | MIE |
| 3.664056E+04 | 3.261219E+04 | 2.274007E+04 | 1.196599E+04 | 11 | 1 | MIE |
| 4.420038E+03 | 1.111399E+03 | 4.425408E+02 | 4.084662E+02 | 11 | 2 | MIE |
| 1.824226E+02 | 6.822610E+00 | 1.869038E+02 | 5.694798E+02 | 11 | 3 | MIE |
| 1.042305E+02 | 3.362055E+02 | 6.213533E+01 | 1.583089E+02 | 11 | 4 | MIE |
| 4.438494E+01 | 7.743587E+01 | 3.465678E+01 | 3.763888E+01 | 11 | 5 | MIE |
| 2.840506E+01 | 1.713435E+01 | 2.285865E+01 | 9.120096E+00 | 11 | 6 | MIE |
| 1.786871E+01 | 7.820148E+00 | 1.290013E+01 | 6.586546E+00 | 11 | 7 | MIE |
| 7.157728E+00 | 3.356980E+00 | 4.099422E+00 | 3.097812E+00 | 11 | 8 | MIE |
| 3.954762E+00 | 6.248101E+00 | 5.813030E+00 | 1.737017E+00 | 11 | 9 | MIE |
| 9.293572E+00 | 1.986561E+01 | 2.092599E+01 | 1.494336E+01 | 11 | 10 | MIE |
| 1.653713E+01 | 2.106733E+01 | 1.172149E+01 | 1.857334E+00 | 11 | 11 | MIE |
| 1.841253E+01 | 4.422441E+01 | 4.071344E+01 | 1.685247E+01 | 11 | 12 | MIE |
| 7.256584E+00 | 9.080470E+00 | 0.000000E+00 | 0.000000E+00 | 11 | 13 | MIE |

4.5 ALGOL Listing: RRA-42

```
BEGIN FILE OUT PRINT 4 (2,15);INTEGER XRAZQ,VVUNU,FZOVC,LKNJA,DKVQK,QRA        2000    0000
                                                        START OF SEGMENT **********    2
*I,LJLOU,GCPOV;INTEGER ARRAY ZIKLA,QNCCL [0 :12];FORMAT HHFRK ("TIME ON         3000    0003
                                                        START OF SEGMENT **********    3
",I4,X96,I2,X1,A3," 19",A2),CHGUB ("TIME OFF ",I4,X30,"PROC. TIME =",I1        4000    0005
0," SECS",X20,"I/O TIME =",I10," SECS");DEFINE BLZAT =LJLOU +FZOVC DIV 2       5000    0005
                                                        3 IS   28 LONG, NEXT SEG    2
16000;GCPOV +FZOVC MOD 216000 /3600 #;FILL ZIKLA [*]WITH 0,31,59,90,120,       6000    0005
                                                        START OF SEGMENT **********    4
151,181,212,243,273,304 ,334,366;FILL QNCCL [*]WITH 0,"JAN","FEB","MAR",       7000    0007
                                                        4 IS   13 LONG, NEXT SEG    2
                                                        START OF SEGMENT **********    5
"APR","MAY","JUN","JUL","AUG","SEP","OCT","NOV","DEC";FZOVC +TIME (1);LK       8000    0009
                                                        5 IS   13 LONG, NEXT SEG    2
NJA +TIME (2);DKVQK +TIME (3);VVUNU +TIME (0);IF (10×VVUNU.[18:6]+VVUNU.       9000    0010
[24:6];MOD 4 =0 THEN FOR XRAZQ +2 STEP 1 UNTIL 12 DO ZIKLA[XRAZQ]+ZIKLA[      10000    0015
XRAZQ]+1 ;QRANI +100 ×VVUNU .[30 :6]+10 ×VVUNU .[36 :6]+VVUNU .[42 :6];X      11000    0019
RAZQ +1;WHILE QRANI >ZIKLA [XRAZQ]DO XRAZQ +XRAZQ +1;QRANI +QRANI -ZIKLA      12000    0027
[XRAZQ -1];BLZAT;WRITE (PRINT[PAGE],HHFRK,100×LJLOU+GCPOV,QRANI,QNCCL[X      13000    0031
RAZQ],VVUNU.[18:12]);                                                         14000    0047
BEGIN                                                                      00001000    0053
FILE    CAPP  (2,10);                                                                  0053
                                                        START OF SEGMENT **********    6
SAVE FILE OUT PUNCH (2,10,SAVE 200);                                                   0003
FILE XXXXXX 2(2,15);                                                       00005000    0007
FILE TAPE1 2(2,15);                                                        00006000    0010
FILE TAPE2 2(2,15);                                                        00007000    0014
FILE TAPE3 2(2,15);                                                        00008000    0017
FILE TAPE4 2(2,15);                                                        00009000    0021
FILE TAPE5 2(2,15);                                                        00010000    0024
```

```
FILE TAPE6 2(2,15);                                                        00011000   0029
FILE TAPE7 2(2,15);                                                        00012000   0031
FILE TAPE8 2(2,15);                                                        00013000   0035
FILE TAPE9 2(2,15);                                                        00014000   0038
FILE TAPE10 2(2,15);                                                       00015000   0042
FILE TAPE11 2(2,15);                                                       00016000   0045
FILE TAPE12 2(2,15);                                                       00017000   0049
FILE TAPE13 2(2,15);                                                       00018000   0052
FILE TAPE14 2(2,15);                                                       00019000   0056
FILE TAPE15 2(2,15);                                                       00020000   0059
FILE TAPE16 2(2,15);                                                       00021000   0063
SWITCH FILE FILESW←XXXXXX,TAPE1,TAPE2,TAPE3,TAPE4,TAPE5,TAPE6,TAPE7,       00022000   0066
   TAPE8,TAPE9,TAPE10,TAPE11,TAPE12,TAPE13,TAPE14,TAPE15,TAPE16;           00023000   0078
LABEL  FINIS;                                                              00024000   0089
REAL ARRAY  DATA[0:63,0:511];    COMMENT USED WITH DATA STATEMENTS ONLY;   00025000   0089
REAL Q,XPR;    INTEGER K;                                                  00026000   0091
FORMAT F(//////"STOP / PAUSE  NO. ",I5), OKTL(2560);                       00027000   0091
                                                              START OF SEGMENT **********    7
                                                                7 IS   17 LONG, NEXT SEG    6
REAL PROCEDURE INT(ARG1);          VALUE ARG1;        REAL ARG1;           00028000   0091
   INT←SIGN(ARG1)×ENTIER(ABS(ARG1));                                       00029000   0091
REAL PROCEDURE TANH(ARG1);         VALUE ARG1;        REAL ARG1;           00030000   0099
   TANH←((Q←EXP(ARG1×2))-1)/(Q+1);                                         00031000   0099
REAL PROCEDURE MAX(ARG1,ARG2);     VALUE ARG1,ARG2;   REAL ARG1,ARG2;      00032000   0105
   MAX←IF ARG1≥ARG2 THEN ARG1 ELSE ARG2;                                   00033000   0105
REAL PROCEDURE MIN(ARG1,ARG2);     VALUE ARG1,ARG2;   REAL ARG1,ARG2;      00034000   0110
   MIN←IF ARG1≤ARG2 THEN ARG1 ELSE ARG2;                                   00035000   0110
REAL PROCEDURE DIM(ARG1,ARG2);     VALUE ARG1,ARG2;   REAL ARG1,ARG2;      00036000   0115
   DIM←MAX(ARG1-ARG2,0);                                                   00037000   0115
REAL PROCEDURE TSIGN(ARG1,ARG2);   VALUE ARG1,ARG2;   REAL ARG1,ARG2;      00038000   0119
   TSIGN←SIGN(ARG2)×ABS(ARG1);                                             00039000   0119
REAL PROCEDURE LOG(ARG1);          VALUE ARG1;        REAL ARG1;           00040000   0124
```

```
   LOG+LN[ARG1]/2.30258509298;                                          00041000    0124
PROCEDURE ERROR[ARG1];            VALUE ARG1;        REAL ARG1;         00042000    0129
BEGIN WRITE[PRINT,F,ARG1]; GO TO FINIS END;                             00043000    0129
PROCEDURE MAINPRO;                                                      00044000    0138
BEGIN                                                                   00045000    0138
OWN REAL ARRAY SVW1[0:400],SVW2[0:400],SVA1[0:A00],SVA2[0:400],         00046000    0138
                                                          START OF SEGMENT **********    8
 SVSA1[0:400],SVSA2[0:400],SVSB1[0:400],SVSB2[0:400],SVS11[0:400],      00047000    0009
 SVS12[0:A00],SVS21[0:400],SVS22[0:A00],SVRENT1[0:100],                 00048000    0020
 SVRENT2[0:100],SVTHET[0:100],SVS1RE[0:100],SVS1IM[0:100],              00049000    0029
 SVS2RE[0:100],SVS2IM[0:100],SVENTAVG[0:100],SVPI[0:400],               00050000    0038
 SVTAU[0:A00],SVRSA2[0:A00],SVRSB2[0:400],SVURSA[0:A00],                00051000    0047
 SVURSR[0:A00],SVRSA[0:400],SVRSR[0:A00],SVENT3[0:100],                 00052000    0056
 SVENTA[0:100],SVPOLAR[0:100];                                          00053000    0065
OWN INTEGER JNPMOB,JKK,JLPROBN,JKFG,JKFF,JKFH,JNEXES,JIPOWER,JKL,       00054000    0069
 JKOUNT,JN,JN1,JN2,JKEEP,JK,JI,JKFG1,JKFG2,JKFF1,JKFF2,JNK;             00055000    0069
OWN REAL JPM1,JPM2,JOTHET1,JOTHET2,JOTHET3,JCHANG1,JCHANG2,JOECIDE,     00056000    0069
 JOPTION,JX,JOTH,JOTHETA,JOTHET5,JOTHET6,JSN,JCN,JPOWP,JPOW,JE,JHSIN,   00057000    0069
 JHCOS,JAREAL,JAIMA,JBB1,JBB2,JBBB,JBC1,JBC2,JRO1,JRO2,JOIV,JTEST2,     00058000    0069
 JPN,JPM1,JPN2,JBA1,JBA2,JTEST1,JTHETA,JCTHETA,JSTHETA,JPIO,JTAUO,      00059000    0069
 JCOF,JEXKROS,JSCKROS,JCOEPH,JTI;                                       00060000    0069
FORMAT FL50[2I4],                                                       00061000    0069
                                                          START OF SEGMENT **********    9
FL60[R18,12],                                                           00062000    0069
FL70[2R18,12,5R5,2,I4],                                                 00063000    0069
FL80[I5],                                                               00064000    0069
FL90[2R18,12],                                                          00065000    0069
FL55[///X10,"TERMINATION CONDITIONS NOT SATISFIED"],                    00066000    0069
FL65(/X10,"SIZE PARAMETER = ",S1,E12,5,X11,"OTHET1 = ",S0,R5.2,X11,     00067000    0069
 "OTHET2 = ",R5,2,X11,"OTHET3 = ",R5,2),                                00068000    0069
FL75[/X35,"INDEX OF REFRACTION = [",R12,6," , ",R12,6," ]"),            00069000    0069
FL85[/X3,"SCATTERING ANGLE",X 8,"I1",X13,"I2",X13,"I3",X13,"I4",X12,    00070000    0069
```

```
 "IAVG",X7,"POLARIZATION"),                                          00071000   0069
FL95(X8,R6,2,X4,S1,6E15,4 ),                                         00072000   0069
FL105(/X1,"MIE COEFFICIENTS AND SQUARES FOR SIZE PARAMETER = ",S1,E12.5)  00073000   0069
,                                                                    00074000   0069
FL115(/X10,"N",X12,"RE(SA)",X6,"IM(SA)",X8 ,"RE(SB)",X6,"IM(SB)",X11,  00075000   0069
 "SA2",X13,"SB2"),                                                   00076000   0069
FL125(X7,I3,X7,"(",S1,E11.4," , ",E11,4,")",X2,"(",E11,4," , ",S1,E11,4,  00077000   0069
")",X5,S1,E11.4,X5,S1,E11,4),                                        00078000   0069
FL135(/X1,"EXTINCTION EFFICIENCY = ",S1,E12,6 ),                     00079000   0069
FL145(/X1,"SCATTERING EFFICIENCY = ",S1,E12.6 ),                     00080000   0069
FL155(" "/X28,                                                       00081000   0069
 "RADIATION RESEARCH ASSOCIATES , FORT WORTH , TEXAS , PROCEDURE ",  00082000   0069
 "RRA-A2"),                                                          00083000   0069
FL165(/X39,"ANALYSIS OF MIE SCATTERING - PROBLEM NUMBER ",I5),       00084000   0069
FL175(/X3,"SCATTERING ANGLE",X7,"RE(S1)",X8,"IM(S1)",X10,"RE(S2)",X8,  00085000   0069
 "IM(S2)"),                                                          00086000   0069
FL185(X8,R6,2,X7,"(",S1,E11.4," , ",E11.4,")",XA,"(",E11,4," , ",S1,  00087000   0069
 E11,4,")"),                                                         00088000   0069
FL195(/),                                                            00089000   0069
FL205(AR10.2,X8,I4,IA," MIE"),                                       00090000   0069
                                                   9 IS  260 LONG, NEXT SEG    8
                                                START OF SEGMENT **********   10
FL215(S1,4F15,6 ,X8,I4,I4," MIE"),                                   00091000   0069
FL225(S1,3E18,6 ,X14,I4,X4," MIE"),                                  00092000   0069
FL235(/X3,"MIE AMPLITUDE FUNCTIONS"),                                00093000   0069
FL245(" "/X10,                                                       00094000   0069
 "RADIATION RESEARCH ASSOCIATES , FORT WORTH , TEXAS , PROCEDURE ",  00095000   0069
 "RRA-A2"),                                                          00096000   0069
FL255(/X21,"ANALYSIS OF MIE SCATTERING - PROBLEM NUMBER ",I5),       00097000   0069
FL265(/X17,"INDEX OF REFRACTION = (",R12,6," , ",R12,6," )"),        00098000   0069
FL275(/X10,"SIZE PARAMETER = ",S1,E12,5);                            00099000   0069
                                                  10 IS   82 LONG, NEXT SEG    8
```

```
LIST LIST1(JNPROB);                                                      00100000   0069
LIST LIST2(JPM1,JPM2,JOTHET1,JOTHET2,JOTHET3,JCHANG1,JCHANG2,JLPROBN);   00101000   0075
LIST LIST3(JOECIDE,JOPTION);                                             00102000   0089
LIST LIST4(JNEXES,JIPOWER);                                              00103000   0096
LIST LIST5(JLPROBN);                                                     00104000   0103
LIST LIST6(JPM1,JPM2);                                                   00105000   0108
LIST LIST7(JX);                                                          00106000   0115
LIST LIST8(JX,JOTHET1,JOTHET2,JOTHET3);                                  00107000   0120
LIST LIST9(SVTHET[JI],SVRENT1[JI],SVRENT2[JI],SVENT3[JI],SVENT4[JI],SVEN 00108000   0129
TAVG[JI],SVPOLAR[JI]);                                                   00109000   0136
LIST LIST10(JEXKROS);                                                    00110000   0144
LIST LIST11(JSCKROS);                                                    00111000   0149
LIST LIST12(JX,JEXKROS,JSCKROS,JLPROBN);                                 00112000   0154
LIST LIST13(SVENTAVG[JI],SVENTAVG[JI+1],SVENTAVG[JI+2],SVENTAVG[JI+3],   00113000   0163
 JLPROBN,JNK);                                                           00114000   0172
LIST LIST14(JI,SVRSA[JI],SVURSA[JI],SVRSB[JI],SVURSB[JI],SVRSA2[JI],SVRS 00115000   0177
B2[JI]);                                                                 00116000   0187
LIST LIST15(SVTHET[JI],SVS1RE[JI],SVS1IM[JI],SVS2RE[JI],SVS2IM[JI]);     00117000   0191
LIST LIST16(SVTHET[JI],SVTHET[JI+1],SVTHET[JI+2],SVTHET[JI+3],SVTHET[    00118000   0203
 JI+4],SVTHET[JI+5],JLPROBN,JNK);                                        00119000   0212
BEGIN                                                                    00120000   0221
LABEL L18,L103,L106,L3,L5,L21,L23,L81,L7,L17;                            00121000   0221
                                                      START OF SEGMENT **********   11
READ(CARD,FL80,LIST1)[FINIS];                                            00122000   0000
JKK←1;                                                                   00123000   0004
DO BEGIN                                                                 00124000   0005
  READ(CARD,FL70,LIST2)[FINIS];                                          00125000   0005
  JPM2←-JPM2;                                                            00126000   0010
  JKFG←INT(JCHANG1/JOTHET1);                                             00127000   0011
  JKFF←INT((JCHANG2-JCHANG1)/JOTHET2);                                   00128000   0013
  JKFH←INT((180-JCHANG2)/JOTHET3);                                       00129000   0015
  JKFF←JKFF+JKFG;                                                        00130000   0017
```

```
JKFH+JKFH+JKFF;                                                        00131000   0016
READ(CARD,FL90,LIST3)[FINIS];                                          00132000   0020
READ(CARD,FL50,LIST4)[FINIS];                                          00133000   0024
JKL+I;                                                                 00134000   0029
DO BEGIN                                                               00135000   0030
  WRITE(PRINT[PAGE]);                                                  00136000   0030
  WRITE(PRINT,FL155);                                                  00137000   0033
  WRITE(PRINT,FL165,LIST5);                                            00138000   0036
  WRITE(PRINT,FL75,LIST6);                                             00139000   0039
  READ(CARD,FL60,LIST7)[FINIS];                                        00140000   0042
  JDTH+I.2×JX+9;                                                       00141000   0047
  WRITE(PRINT,FL65,LIST8);                                             00142000   0049
  JDTHET4+JDTHET1×.017453329;                                          00143000   0052
  JDTHET5+JDTHET2×.017453329;                                          00144000   0053
  JDTHET6+JDTHET3×.017453329;                                          00145000   0054
  JSN+SIN(JX);                                                         00146000   0056
  JCN+COS(JX);                                                         00147000   0057
  JPOWP+JPM2×JX;                                                       00148000   0058
  JPOW+JPM1×JX;                                                        00149000   0059
  JE+2.71828;                                                          00150000   0061
  JHSIN+((JE)*JPOWP-(1/JE)*JPOWP)/2;                                   00151000   0061
  JHCOS+((JE)*JPOWP+(1/JE)*JPOWP)/2;                                   00152000   0068
  JAREAL+(SIN(JPOW)×COS(JPOW))/(SIN(JPOW)×SIN(JPOW)+JHSIN×JHSIN);      00153000   0074
  JAIMA+(JHSIN×JHCOS)/(SIN(JPOW)×SIN(JPOW)+JHSIN×JHSIN);               00154000   0079
  SVW1[1]+(1/JX)×JSN;                                                  00155000   0083
  SVW2[1]+(1/JX)×JCN;                                                  00156000   0086
  SVW1[1]+SVW1[1]-JCN;                                                 00157000   0088
  SVW2[1]+SVW2[1]+JSN;                                                 00158000   0090
  SVW1[2]+(3/JX)×SVW1[1];                                              00159000   0092
  SVW2[2]+(3/JX)×SVW2[1];                                              00160000   0094
  SVW1[2]+SVW1[2]-JSN;                                                 00161000   0097
  SVW2[2]+SVW2[2]-JCN;                                                 00162000   0099
```

```
JBB1←JPM1×JX;                                          00163000   0101
JBB2←-JPM2×JX;                                         00164000   0102
JBBB←JBB1*2+JBB2*2;                                    00165000   0104
JBB1←JBB1/JBBB;                                        00166000   0106
JBB2←-JBB2/JBBB;                                       00167000   0107
JBC1←JBB1-JAREAL;                                      00168000   0109
JBC2←JBB2-JAIMA;                                       00169000   0110
JBBB←JBC1*2+JBC2*2;                                    00170000   0111
JBC1←JBC1/JBBB;                                        00171000   0113
JBC2←-JBC2/JBBB;                                       00172000   0115
SVA1[1]←JBC1-JBB1;                                     00173000   0116
SVA2[1]←JBC2-JBB2;                                     00174000   0118
JKOUNT←0;                                              00175000   0120
JBBB←JPM1*2+JPM2*2;                                    00176000   0120
JBB1←(SVA1[1]×JPM1-JPM2×SVA2[1])/JBBB+1/JX;            00177000   0123
JBB2←(SVA2[1]×JPM1+JPM2×SVA1[1])/JBBB;                 00178000   0127
L103: JBC1←((JBB1×SVM1[1])-JSN;                        00179000   0130
JBC2←JBB2×SVM1[1];                                     00180000   0133
JBD1←JBB1×SVM1[1]-JBB2×SVM2[1];                        00181000   0134
JBD2←JBB1×SVM2[1]+JBB2×SVM1[1];                        00182000   0137
JBD1←JBD1-JSN;                                         00183000   0140
JBD2←JBD2-JCN;                                         00184000   0141
JDIV←JBD1*2+JBD2*2;                                    00185000   0142
IF JKOUNT≠0 THEN GO TO L106;                           00186000   0144
SVSA1[1]←(JBD1×JBC1+JBD2×JBC2)/JDIV;                   00187000   0146
SVSA2[1]←(JBD1×JBC2-JBD2×JBC1)/JDIV;                   00188000   0149
JKOUNT←1;                                              00189000   0156
JBB1←(SVA1[1]×JPM1+SVA2[1]×JPM2)+1/JX;                 00190000   0157
JBB2←(SVA2[1]×JPM1-SVA1[1]×JPM2);                      00191000   0160
GO TO L103;                                            00192000   0163
L106: SVSB1[1]←(JBD1×JBC1+JBD2×JBC2)/JDIV;             00193000   0164
SVSB2[1]←(JBD1×JBC2-JBD2×JBC1)/JDIV;                   00194000   0167
```

```
JTEST2←(.1)*JIPOWER;                                          00195000   0170
JN←1;                                                         00196000   0173
DO BEGIN                                                      00197000   0174
  JPN←JN;                                                     00198000   0174
  JN1←JN+1;                                                   00199000   0174
  JPN1←JN1;                                                   00200000   0176
  JN2←JN+2;                                                   00201000   0176
  JPN2←JN2;                                                   00202000   0176
  SVW1[JN2]←((2×JPN2-1)/JX)×SVW1[JN1]-SVW1[JN];               00203000   0178
  SVW2[JN2]←((2×JPN2-1)/JX)×SVW2[JN1]-SVW2[JN];               00204000   0183
  JBB1←JPN1×JX;                                               00205000   0187
  JBB2←-JPN2×JX;                                              00206000   0188
  JBBB←JBB1*2+JBB2*2;                                         00207000   0190
  JBC1←-JPN1×(JBB1/JBBB);                                     00208000   0192
  JBC2←JPN1×(JBB2/JBBB);                                      00209000   0194
  JBD1←-JBC1-SVA1[JN];                                        00210000   0196
  JBD2←-JBC2-SVA2[JN];                                        00211000   0197
  JBBB←JBD1*2+JBD2*2;                                         00212000   0199
  JBD1←JBD1/JBBB;                                             00213000   0201
  JBD2←-JBD2/JBBB;                                            00214000   0203
  SVA1[JN1]←JBC1+JBD1;                                        00215000   0204
  SVA2[JN1]←JBC2+JBD2;                                        00216000   0206
  JBBB←JPM1*2+JPM2*2;                                         00217000   0208
  JBB1←(SVA1[JN1]×JPM1-SVA2[JN1]×JPM2)/JBBB;                  00218000   0210
  JBB2←(JPM1×SVA2[JN1]+JPM2×SVA1[JN1])/JBBB;                  00219000   0213
  JBC1←(JBB1+JPN1/JX)×SVW1[JN1]-SVW1[JN];                     00220000   0216
  JBC2←JBB2×SVW1[JN1];                                        00221000   0220
  JBD1←(JBB1+JPN1/JX);                                        00222000   0221
  JBD2←JBB2;                                                  00223000   0223
  JBA1←JBD1×SVW1[JN1]-JBD2×SVW2[JN1]-SVW1[JN];                00224000   0224
  JBA2←JBD1×SVW2[JN1]+JBD2×SVW1[JN1]-SVW2[JN];                00225000   0227
  JBBB←JBA1*2+JBA2*2;                                         00226000   0231
```

```
    SVSA1[JN1]+(JBC1×JBA1+JBC2×JBA2)/JBBR;              00227000    0233
    SVSA2[JN1]+(JBC2×JBA1-JBC1×JBA2)/JBBR;              00228000    0236
    JBB1+SVA1[JN1]×JPM1+SVA2[JN1]×JPM2;                 00229000    0239
    JBB2+SVA2[JN1]×JPM1-SVA1[JN1]×JPM2;                 00230000    0242
    JBC1+(JBB1+JPN1/JX)×SVW1[JN1]-SVW1[JN1];            00231000    0245
    JBC2+JBB2×SVW1[JN1]];                               00232000    0248
    JBD1+(JBB1+JPN1/JX);                                00233000    0250
    JBD2+JBB2;                                          00234000    0251
    JBA1+JBD1×SVW1[JN1]-JBD2×SVW2[JN1]-SVW1[JN1];       00235000    0252
    JBA2+JBD1×SVW2[JN1]+JBD2×SVW1[JN1]-SVW2[JN1];       00236000    0256
    JBBR+JBA1*2+JBA2*2;                                 00237000    0259
    SVSB1[JN1]+(JBC1×JBA1+JBC2×JBA2)/JBBR;              00238000    0261
    SVSB2[JN1]+(JBC2×JBA1-JBC1×JBA2)/JBBR;              00239000    0265
    SVRSA[JN]+SVSA1[JN];                                00240000    0268
    SVRSB[JN]+SVSB1[JN];                                00241000    0269
    SVURSA[JN]+SVSA2[JN];                               00242000    0271
    SVURSB[JN]+SVSB2[JN];                               00243000    0274
    SVRSA2[JN]+SVSA1[JN]*2+SVSA2[JN]*2;                 00244000    0276
    SVRSB2[JN]+SVSB1[JN]*2+SVSB2[JN]*2;                 00245000    0279
    JTEST1+(SVRSA2[JN]+SVRSB2[JN])/JPN;                 00246000    0282
    IF JTEST1<JTEST2 THEN GO TO L3;                     00247000    0284
    IF JPN≥JNTH THEN GO TO L3;                          00248000    0286
    END UNTIL (JN+(JN+1))>300;                          00249000    0287
  WRITE(PRINT,FL55);                                    00250000    0289
  L3: JKEEP+INT(JPN);                                   00251000    0292
  JK+1;                                                 00252000    0294
  JTHETA+0;                                             00253000    0295
  L5: JCTHETA+COS(JTHETA);                              00254000    0295
  JSTHETA+SIN(JTHETA);                                  00255000    0297
  SVS11[JK]+0;                                          00256000    0298
  SVS12[JK]+0;                                          00257000    0299
  SVS21[JK]+0;                                          00258000    0301
```

```
SVS22[JK]+0;                                                             00259000   0302
JPIO+0;                                                                  00260000   0303
SVPI[1]+1;                                                               00261000   0304
SVPI[2]+3×JCTHETA;                                                       00262000   0305
JTAU0+0;                                                                 00263000   0307
SVTAU[1]+JCTHETA;                                                        00264000   0308
SVTAU[2]+3×(JCTHETA×JCTHETA-JSTHETA×JSTHETA);                            00265000   0309
JN+1;                                                                    00266000   0312
DO BEGIN                                                                 00267000   0313
  JPN+JN;                                                                00268000   0313
  JN1+JN+1;                                                              00269000   0314
  JPN1+JN1;                                                              00270000   0315
  JN2+JN+2;                                                              00271000   0316
  JPN2+JN2;                                                              00272000   0317
  SVPI[JN2]+((2×JPN2-1)/(JPN2-1))×SVPI[JN1]×JCTHETA-(JPN2/(JPN2-1))×     00273000   0318
   SVPI[JN];                                                             00274000   0323
  SVTAU[JN2]+JCTHETA×(SVPI[JN2]-SVPI[JN])-(2×JPN2-1)×JSTHETA×            00275000   0324
   JSTHETA×SVPI[JN1]+SVTAU[JN];                                          00276000   0328
  JBB1+SVSA1[JN]×SVPI[JN];                                               00277000   0331
  JBB2+SVSA2[JN]×SVPI[JN];                                               00278000   0333
  JBC1+SVSB1[JN]×SVTAU[JN];                                              00279000   0335
  JBC2+SVSB2[JN]×SVTAU[JN];                                              00280000   0336
  JCOF+(2×JPN+1)/(JPN×(JPN+1));                                          00281000   0338
  SVS11[JK]+JCOF×(JBB1+JBC1)+SVS11[JK];                                  00282000   0341
  SVS12[JK]+JCOF×(JBB2+JBC2)+SVS12[JK];                                  00283000   0344
  JBB1+SVSB1[JN]×SVPI[JN];                                               00284000   0347
  JBB2+SVSB2[JN]×SVPI[JN];                                               00285000   0349
  JBC1+SVSA1[JN]×SVTAU[JN];                                              00286000   0351
  JBC2+SVSA2[JN]×SVTAU[JN];                                              00287000   0353
  SVS21[JK]+JCOF×(JBB1+JBC1)+SVS21[JK];                                  00288000   0354
  SVS22[JK]+JCOF×(JBB2+JBC2)+SVS22[JK];                                  00289000   0357
  END UNTIL (JN+(JN+1))>JKEEP;                                           00290000   0360
```

```
IF JKFG<JK THEN GO TO L21;                                        00291000   0363
JTHETA+JTHETA+JDTHETA;                                            00292000   0364
GO TO L23;                                                        00293000   0365
L21: IF JKFF<JK THEN GO TO L41;                                   00294000   0366
JTHETA+JTHETA+JDTHET5;                                            00295000   0367
GO TO L23;                                                        00296000   0368
L41: IF JKFH<JK THEN GO TO L7;                                    00297000   0369
JTHETA+JTHETA+JDTHET6;                                            00298000   0370
L23: JK+JK+1;                                                     00299000   0371
GO TO L5;                                                         00300000   0373
L7: JEXKROS+0;                                                    00301000   0373
JSCKROS+0;                                                        00302000   0374
JCOEPH+2/(JX×JX);                                                 00303000   0375
JI+1;                                                             00304000   0377
DO BEGIN                                                          00305000   0378
  JTI+JI;                                                         00306000   0378
  JEXKROS+JCOEPH×((2×JTI+1)×(SVRSA[JI]+SVRSB[JI]))+JEXKROS;       00307000   0378
  JSCKROS+JCOEPH×((2×JTI+1)×(SVRSA2[JI]+SVRSB2[JI]))+JSCKROS END  00308000   0383
 UNTIL (JI+(JI+1))>JKEEP;                                         00309000   0387
JI+1;                                                             00310000   0389
DO BEGIN                                                          00311000   0390
  SVRENT1[JI]+SVS11[JI]*2+SVS12[JI]*2;                            00312000   0390
  SVRENT2[JI]+SVS21[JI]*2+SVS22[JI]*2;                            00313000   0393
  SVENT3[JI]+SVS11[JI]×SVS21[JI]+SVS12[JI]×SVS22[JI];             00314000   0396
  SVENT4[JI]+(SVS11[JI]×SVS22[JI]-SVS21[JI]×SVS12[JI]);           00315000   0400
  SVPOLAR[JI]+(SVRENT1[JI]-SVRENT2[JI])/(SVRENT1[JI]+SVRENT2[     00316000   0404
   JI]);                                                          00317000   0406
  SVENTAVG[JI]+(SVRENT1[JI]+SVRENT2[JI])/2 END UNTIL (JI+(JI+1))> 00318000   0408
 JK;                                                              00319000   0412
SVTHET[1]+0;                                                      00320000   0413
JKFG1+JKFG+1;                                                     00321000   0414
JKFG2+JKFG+2;                                                     00322000   0415
```

```
JKFF1+JKFF+1;                                                    00323000   0416
JKFF2+JKFF+2;                                                    00324000   0416
JI+2;                                                            00325000   0419
DO BEGIN                                                         00326000   0420
  SVTHET[JI]+SVTHET[JI-1]+JOTHETA END UNTIL (JI+(JI+1))>JKFG1;   00327000   0420
JI+JKFG2;                                                        00328000   0424
DO BEGIN                                                         00329000   0425
  SVTHET[JI]+SVTHET[JI-1]+JOTHETS END UNTIL (JI+(JI+1))>JKFF1;   00330000   0425
JI+JKFF2;                                                        00331000   0430
DO BEGIN                                                         00332000   0431
  SVTHET[JI]+SVTHET[JI-1]+JOTHET6 END UNTIL (JI+(JI+1))>JK;      00333000   0431
JI+1;                                                            00334000   0435
DO BEGIN                                                         00335000   0436
  SVTHET[JI]+SVTHET[JI]*57.29578 END UNTIL (JI+(JI+1))>JK;       00336000   0436
WRITE(PRINT,FL85);                                               00337000   0440
WRITE(PRINT,FL195);                                              00338000   0443
JI+1;                                                            00339000   0446
DO BEGIN                                                         00340000   0447
  SVS1RE[JI]+SVS11[JI];                                          00341000   0447
  SVS1IM[JI]+SVS12[JI];                                          00342000   0449
  SVS2RE[JI]+SVS21[JI];                                          00343000   0450
  SVS2IM[JI]+SVS22[JI] END UNTIL (JI+(JI+1))>JK;                 00344000   0452
JI+1;                                                            00345000   0455
DO BEGIN                                                         00346000   0456
  WRITE(PRIN.,FL95,LIST9);                                       00347000   0456
  END UNTIL (JI+(JI+1))>JK;                                      00348000   0459
WRITE(PRINT,FL135,LIST10);                                       00349000   0462
WRITE(PRINT,FL145,LIST11);                                       00350000   0465
WRITE(PUNCH,FL225,LIST12);                                       00351000   0468
JNK+0;                                                           00352000   0471
JI+1;                                                            00353000   0472
DO BEGIN                                                         00354000   0473
```

```
      JNK+JNK+1;                                              0473
      WRITE(PUNCH,FL215,LIST13);                              0474
      END UNTIL (JI+(JI+4))>JK;                               0477
    IF JDECIDE≠0 THEN GO TO L17;                              0480
    WRITE(PRINT[PAGE]);                                       0481
    WRITE(PRINT,FL155);                                       0484
    WRITE(PRINT,FL165,LIST5);                                 0487
    WRITE(PRINT,FL75,LIST6);                                  0490
    WRITE(PRINT,FL105,LIST7);                                 0493
    WRITE(PRINT,FL115);                                       0496
    WRITE(PRINT,FL195);                                       0499
    JI+1;                                                     0502
    DO BEGIN                                                  0503
      WRITE(PRINT,FL125,LIST14);                              0503
      END UNTIL (JI+(JI+1))>JKEEP;                            0506
    L17: IF JOPTION≠0 THEN GO TO L18;                         0509
    WRITE(PRINT[PAGE]);                                       0510
    WRITE(PRINT,FL245);                                       0513
    WRITE(PRINT,FL255,LIST5);                                 0516
    WRITE(PRINT,FL265,LIST6);                                 0519
    WRITE(PRINT,FL275,LIST7);                                 0522
    WRITE(PRINT,FL235);                                       0525
    WRITE(PRINT,FL175);                                       0528
    WRITE(PRINT,FL195);                                       0531
    JI+1;                                                     0534
    DO BEGIN                                                  0535
      WRITE(PRINT,FL185,LIST15);                              0535
      END UNTIL (JI+(JI+1))>JK;                               0536
L18:END UNTIL (JKL+(JKL+1))>JNEXES;                           0543
   JNK+0;                                                     0546
   JI+1;                                                      0547
   DO BEGIN                                                   0547
```

```
      JNK←JNK+1;                                                          00387000    0547
      WRITE(PUNCH,FL205,LIST16);                                          00388000    0549
      END UNTIL (JI←(JI+6))>JK;                                           00389000    0552
         END UNTIL (JKK←(JKK+1))>JNPROB;                                  00390000    0554
   END END;                                                               00391000    0556
                                                                 11 IS  560 LONG, NEXT SEG    8
                                                                  8 IS  229 LONG, NEXT SEG    6
 COMMENT  INITIALIZING BLOCK;                                             00392000    013C
 BEGIN                                                                                013E
 FILE IN CARDS (2,10);                                                                0139
                                                              START OF SEGMENT **********   12
 LABEL L1,L2;L1:READ(CARDS,10,ONCCL[*])[L2];WRITE(CARD,10,ONCCL[*]);                  0003
 GO TO L1;L2:REWIND(CARD);CLOSE(CARDS,RELEASE) ;                                      0011
 END ;                                                                                0015
                                                                 12 IS   19 LONG, NEXT SEG    6
   XPR←Q←K←0;                                                             00393000    0140
 MAINPRO: FINIS:                                                          00394000    0141
 END ;                                                                                0143
                                                                  6 IS  146 LONG, NEXT SEG    2
 LKNJA←(TIME(2)-LKNJA)/60;OKVQK←(TIME(3)-OKVQK)/60;FZOVC←TIME(1);P_4AT;WR     17000   0054
 ITE(PRINT[PAGE]);WRITE(PRINT,CHGUB,100×LJLDU+GCPOV,LKNJA,OKVQK);               18000   0062
 END.                                                                        20000   008C
                                                                  2 IS   83 LONG, NEXT SEG    1
COS IS SEGMENT NUMBER 0013,PRT ADDRESS IS 0305
EXP IS SEGMENT NUMBER 0014,PRT ADDRESS IS 0100
LN IS SEGMENT NUMBER 0015,PRT ADDRESS IS 0106
SIN IS SEGMENT NUMBER 0016,PRT ADDRESS IS 030A
OUTPUT(W) IS SEGMENT NUMBER 0017,PRT ADDRESS IS 0043
BLOCK CONTROL IS SEGMENT NUMBER 0018,PRT ADDRESS IS 0005
INPUT(W) IS SEGMENT NUMBER 0019,PRT ADDRESS IS 0303
X TO THE I IS SEGMENT NUMBER 0020,PRT ADDRESS IS 0306
GO TO SOLVER  IS SEGMENT NUMBER 0021,PRT ADDRESS IS 0112
```

```
ALGOL WRITE   IS SEGMENT NUMBER 0022,PRT ADDRESS IS 0014
ALGOL READ    IS SEGMENT NUMBER 0023,PRT ADDRESS IS 0015
ALGOL SELECT  IS SEGMENT NUMBER 0024,PRT ADDRESS IS 0016
                                                                                  1 IS    2 LONG, NEXT SEG    0
                                                                                 25 IS   69 LONG, NEXT SEG    0
NUMBER OF ERRORS DETECTED =   0.  COMPILATION TIME =   36 SECONDS.
PRT SIZE = 206; TOTAL SEGMENT SIZE =  1521 WORDS; DISK SIZE =  68 SEGS; NO. PGM. SEGS =  25
ESTIMATED CORE STORAGE REQUIREMENT =  7908 WORDS.
```

# V. UTILIZATION INSTRUCTIONS - RRA-45

## 5.1 Description

RRA-45 is designed to calculate macroscopic data for a given particle size distribution by integration over the data generated by RRA-42. The quantities calculated by this code are discussed in Section 2.2. They are the unnormalized volume scattering function, the normalized volume scattering function, the cumulative probability function, the extinction and scattering cross sections, the average cosine, and the scattering cross section computed from the unnormalized volume scattering function. The cosine values for the scattering angles corresponding to values of the cumulative probability function at equal intervals from 0 to 1 are calculated for input into the LITE codes.

The quantities listed above are output on a file designed to be printed. The normalized volume scattering function and the cosines for equal probability intervals are also written on a different file that may be punched on cards for direct input into the LITE codes.

The microscopic data may be input on the same file as the source program or the library tape generated by RRA-42 may be used, designating this tape as input file "TAPE9." Explicit instructions are given in Section 5.3.

As stated earlier the code will accept as input size distributions of three types; these are:

$$n(r) = ar^{\alpha}e^{-br^{\gamma}}; \tag{40}$$

$$\begin{cases} n(r) = a \quad (r_1 < r < r_2) , \\ n(r) = br^{\alpha} \; (r_2 < r) ; \end{cases} \tag{41}$$

and

$$n(r) = \text{tabular data.} \tag{42}$$

For equation 40, a and b may be determined for a particular choice of $\alpha$ and $\gamma$ from the number of particles per unit volume, N. The two equations

$$N = \int_0^{\infty} n(r)dr = \frac{a}{\gamma} b^{-\left(\frac{\alpha+1}{\gamma}\right)} \Gamma \left(\frac{\alpha+1}{\gamma}\right) ,$$

and

$$\frac{d}{dr} n(r) = ar^{\alpha-1} e^{-br^{\gamma}} (\alpha - br^{\gamma}) = 0, \text{ for } b = \frac{\alpha}{\gamma r^{\gamma}} , \; r = r_c ,$$

may be solved simultaneously for a and b. The radius $r_c$ is the mode radius. The quantities a and b must be input into the code.

For equation 41, a and b may be determined for a particular choice of $\alpha$, $r_1$ and $r_2$ by likewise solving

$$N = \int_0^{\infty} n(r)dr .$$

The type of size distribution to be used in a given problem is fixed by the input option parameter CHOOSE defined in Section 5.2. With the use of the parameter OPTION, it is possible to input values of the size distribution for each of the input size parameters.

Two types of numerical integration are available in computing "Cumulative Probability," Equation 32, and "Cross Section from Phase Function," Equation 28. Subroutine GRATER integrates by fitting a quadratic curve through three successive points in the curve and integrating the results analytically. The first two area increments in the integration

are obtained using the trapezoidal rule. In order to define Equation 32 at each point in the curve, two passes through the function must be made by the subroutine. If the curve is very highly peaked in the forward direction, the resulting cumulative probability curve may not be a smoothly increasing function.

When the curve is highly peaked, one may use subroutine GRATRE, which integrates by fitting an exponential curve between two points and integrating analytically. No area increments are obtained by using the trapezoidal rule.

If the function, Equation 27, is not highly peaked in the forward direction, GRATER is sometimes the more accurate integrator. For highly peaked functions, GRATRE is more reliable. The person preparing a problem must determine which method best fits a particular problem.

## 5.2 Input Variables

A listing of the variables required as input to RRA-45 and the formats to be used in preparing a problem deck are given in Table IX.

Table IX Problem Data Deck for RRA-45

| Variable | Description | Format | Card No. |
|---|---|---|---|
| NPROB | Number of problems to be run. Each problem corresponds to a new size distribution. | | |
| NTHETA | Number of angles at which input phase functions are defined. | | |
| NEXES | Number of size parameters to be included in calculations. | 5I6 | *1 |

Table IX. (continued)

| Variable | Description | Format | Card No. |
|---|---|---|---|
| NTAPE | Parameter determining whether X(I), EXKROS (I), SCKROS(I), and PHASE(I) are to be input as cards or chosen from a library tape loaded on file "TAPE 9." Values are read from cards loaded behind program deck for any other value for NTAPE. | | |
| NGRATE | Variable for choosing type of numerical integration in computing "Cumulative Probability" and "Cross Section from Phase Function." If NGRATE=0, subroutine "GRATER" is used. If NGRATRE≠0, subroutine "GRATRE" is used | | |
| XMIN | Input only if NTAPE=0. XMIN is the smallest size parameter to be used in the calculations. | 2E15.6 | 2 |
| XMAX | Input only if NTAPE=0. XMAX is the largest size parameter <u>on tape 9</u>, not necessarily the larges size parameter used in the calculations. | | |
| X(I) | Set of size parameters used in calculations. I=1, NEXES | 3E18.6 | 3 |
| EXKROS(I) | Extinction efficiency for X(I) | | |
| SCKROS(I) | Scattering efficiency for X(I) | | |
| PHASE(I,J) | Phase function $\frac{i_1 + i_2}{2}$ for X(I) and for Jth scattering angle. | 4E15.6 | 4 |
| THETA(J) | Set of scattering angles for which PHASE is defined. Angles must be the same for every X(I). | 6E10.2 | 5 |
| CHOOSE | Parameter for choosing type of size distribution. If CHOOSE is zero, a size distribution of the type shown in Equation 40 is used for n(r). If CHOOSE is any other value, a type as shown in Equation 41 will be used. | | |
| OPTION | Parameter for choosing type of size distribution. If OPTION is zero, program will read tabular data for n(r). For any other value of OPTION, either a distribution as in Equation 40 or as in Equation 41 will be used according to the value of CHOOSE. | 3F6.0 | 6 |

Table IX. (continued)

| Variable | Description | Format | Card No. |
|---|---|---|---|
| DECIDE | Decision for printing out probability values for equal increments and corresponding cosine values. To print out, input zero for DECIDE. Any other value will suppress printout. | | |
| WAVLGH | Wave length of the light incident upon the scattering medium. Input value in microns. | E18.8 | 7 |
| IPROB | Problem number designation. | I6 | |
| NPDIV | Number of probability divisions; e.g. if NPDIV=25, the cosine of the angle corresponding to values of the cumulative probability ranging from 0 to 1 in increments of .04 will be calculated. | I6 | 8 |
| A | Correspond to a in Equation 40. | | |
| ALPHA | Corresponds to $\alpha$ in Equation 40. | 4F18.8 | 9 |
| B | Corresponds to b in Equation 40. | | |
| GAMMA | Corresponds to $\gamma$ in Equation 40. (Input A, ALPHA, B, GAMMA only if CHOOSE is zero. These quantities must be calculated on a basis for N = number of particles per $cm^3$. | | |
| CONST | Corresponds to a in Equation 41. | | |
| XPMAX | Size parameter corresponding to $r_2$ in Equation 41. | 3E18.8<br>F18.8 | 10 |
| A | Corresponds to b in Equation 41. | | |
| ALPHA | Corresponds to $\alpha$ in Equation 41. (Input CONST, XPMAX, A and ALPHA only if CHOOSE is a value other than zero. These values must be calculated on a basis for N = number of particles per $cm^3$. | | |
| ENR(K) | Set of values defining n(r) for all size parameters input. Input only if OPTION is zero. ENR(K) should have units $cm^{-3}\mu^{-1}$. | 5E12.6 | 11 |

* Numbers relate input parameters to cards shown in listing of sample input data.

## 5.3 Input Instructions

Some of the input data for RRA-45 will be obtained from the punched output file produced by running RRA-42. RRA-42 punches out X(I), EXKROS(I), SCKROS(I), PHASE(I,J), and THETA(J) in the exact order they are to be input, provided size parameters have been calculated in increasing order. Provision has been made for input of these parameters from a separate library tape. Thus a tape containing data for a particular refractive index and for a very large range of size parameters X(I) may be used where only those size parameters to be used in the calculation of a particular problem are read from the tape. Data are contained on the tape in the following configuration:

1. One record containing the value of X(1), EXKROS(1), SCKROS(1).
2. NTHETA/4 records containing PHASE(I,J), J=1, NTHETA, four values to a record.
3. Statements 1 and 2 are repeated until all size parameters and corresponding PHASE's are exhausted. Each new X(I) starts a new record and each PHASE(I,1) begins a new record.
4. NTHETA/6 records at end of tape containing THETA(J), J=1, NTHETA, 6 numbers per record. THETA(1) begins a new record.

When using separate library tape (NTAPE=0) as described above, data cards are loaded on the card reader behind the source deck in the following order:

Card 1: NPROB,NTEHTA,NEXES,NTAPE,NGRATE

Card 2: XMIN,XMAX

Card 3: CHOOSE,OPTION,DECIDE

Card 4: WAVLGH, IPROB

Card 5: NPDIV

Card 6: IF OPTION=0 ENR(K) (continued on cards 7, 8, etc.)

IF OPTION≠0

IF CHOOSE=0 A,ALPHA,B,GAMMA

IF CHOOSE≠0 CONST,XPMAX,A,ALPHA

When not using separate library tape (NTAPE=0), data cards are loaded in the following order.

Card 1: NPROB, NTHETA, NEXES, NTAPE, NGRATE

Card 2 through

Card N: Cards containing X(I),EXKROS(I),SCKROS(I),PHASE(I,J), and THETA(J). Load only those size parameters used in calculations, in order of increasing size. These cards must be in exactly the configuration described for these data using a separate library tape.

Card N+1: CHOOSE, OPTION, DECIDE

Card N+2: WAVLGH, IPROB

Card N+3: NPDIV

Card N+4: Same as Card 6 described above.

When using different size distributions with the same set of parametric data, several problems may be run by specifying the number of problems with NPROB. Cards 3, 4, 5 and 6 must be loaded for <u>each</u> problem, each set of four cards immediately following another. Thus, to run an additional problem, cards corresponding to cards 3, 4, 5 and 6 need only to be added to the end of the data deck. This process is repeated for each additional size distribution or wave length to be used in a given run.

The following list gives the file names of the input-output files:

| Input-Output Files | File Name |
|---|---|
| 1. Program deck | CARD |
| 2. Input data | CARD |
| 3. Printed output | PRINT |
| 4. Punched output | PUNCH |

## 5.4 Sample Problem

Table X gives a listing of the problem input data for a RRA-45 sample problem and Table XI lists the printed output obtained from running the sample problem. The second page of the printed output is an optional printout obtained when the option DECIDE was input as zero. Table XII lists the punched card output obtained for the sample problem.

The column designated "Phase Function" in Table XI contains those quantities defined in Equation 27. The "Differential Probability" column contains values defined in Equation 29. Values for "Cumulative Probability" are defined by Equation 32. The optional printout shows the cosine for equal increments in cumulative probability.

The sample problem describes the scattering of light by particles with a size distribution

$$n(r) = 2.373r^{6}\ e^{-1.5r}\ cm^{-3}\ \mu^{-1}$$

where $N = 100\ cm^{-3}$ and $r_{mode} = 4\mu$. A wave length of $5.30\mu$ and index of refraction $1.315 - 0.0143i$ was used. Size parameters used are 0.25, .5(.5)15.

**TABLE X. RRA-45 SAMPLE PROBLEM INPUT DATA (CARD INPUT)**

```
  1     22     26      0      1
   2.500E-01        1.500E&01
0.0    1.0    0.0
       5.30E&00       2
25
         2.373                6.0               1.5               1.0
```

Listing of Tape Input Data Given on the Following 6 Pages

TABLE X. (CONT.)

| | | | | |
|---|---|---|---|---|
| 2.500E-01 | 8.6835E-03 | 3.968E-04 | | 001 |
| 9.557E-06 | 9.533E-06 | 9.462E-06 | 9.346E-06 | 002 |
| 9.185E-06 | 8.985E-06 | 8.335E-06 | 7.539E-06 | 003 |
| 6.693E-06 | 5.898E-06 | 5.247E-06 | 4.815E-06 | 004 |
| 4.649E-06 | 4.764E-06 | 5.139E-06 | 5.726E-06 | 005 |
| 6.449E-06 | 7.218E-06 | 7.941E-06 | 8.529E-06 | 006 |
| 8.912E-06 | 9.046E-06 | | | 007 |
| 5.000E-01 | 2.3774E-02 | 6.207E-03 | | 008 |
| 6.473E-04 | 6.456E-04 | 6.405E-04 | 6.320E-04 | 009 |
| 6.205E-04 | 6.060E-04 | 5.593E-04 | 5.022E-04 | 010 |
| 4.418E-04 | 3.849E-04 | 3.380E-04 | 3.056E-04 | 011 |
| 2.904E-04 | 2.928E-04 | 3.111E-04 | 3.420E-04 | 012 |
| 3.807E-04 | 4.221E-04 | 4.609E-04 | 4.924E-04 | 013 |
| 5.128E-04 | 5.199E-04 | | | 014 |
| 1.000E+00 | 1.2538E-01 | 8.479E-02 | | 015 |
| 4.752E-02 | 4.736E-02 | 4.689E-02 | 4.612E-02 | 016 |
| 4.507E-02 | 4.377E-02 | 3.958E-02 | 3.455E-02 | 017 |
| 2.931E-02 | 2.443E-02 | 2.033E-02 | 1.729E-02 | 018 |
| 1.535E-02 | 1.443E-02 | 1.435E-02 | 1.487E-02 | 019 |
| 1.573E-02 | 1.672E-02 | 1.767E-02 | 1.843E-02 | 020 |
| 1.892E-02 | 1.909E-02 | | | 021 |
| 1.500E+00 | 3.5320E-01 | 2.860E-01 | | 022 |
| 5.758E-01 | 5.732E-01 | 5.656E-01 | 5.532E-01 | 023 |
| 5.362E-01 | 5.153E-01 | 4.495E-01 | 3.729E-01 | 024 |
| 2.958E-01 | 2.263E-01 | 1.693E-01 | 1.262E-01 | 025 |
| 9.575E-02 | 7.554E-02 | 6.275E-02 | 5.487E-02 | 026 |
| 5.005E-02 | 4.706E-02 | 4.518E-02 | 4.401E-02 | 027 |
| 4.336E-02 | 4.316E-02 | | | 028 |
| 2.000E+00 | 7.1730E-01 | 6.158E-01 | | 029 |
| 3.432E+00 | 3.411E+00 | 3.348E+00 | 3.247E+00 | 030 |
| 3.110E+00 | 2.943E+00 | 2.432E+00 | 1.867E+00 | 031 |
| 1.336E+00 | 8.936E-01 | 5.613E-01 | 3.316E+00 | 032 |

TABLE X. (CONT.)

| | | | | |
|---|---|---|---|---|
| 1.835E-01 | 9.361E-02 | 4.255E-02 | 1.676E-02 | 033 |
| 7.242E-03 | 7.803E-03 | 1.371E-02 | 2.107E-02 | 034 |
| 2.682E-02 | 2.897E-02 | | | 035 |
| 2.500E&00 | 1.1715E&00 | 1.044E&00 | | 036 |
| 1.241E&01 | 1.230E&01 | 1.200E&01 | 1.147E&01 | 037 |
| 1.079E&01 | 9.973E&00 | 7.580E&00 | 5.154E&00 | 038 |
| 3.132E&00 | 1.699E&00 | 8.265E-01 | 3.681E-01 | 039 |
| 1.642E-01 | 9.433E-02 | 8.769E-02 | 1.103E-01 | 040 |
| 1.477E-01 | 1.922E-01 | 2.376E-01 | 2.769E-01 | 041 |
| 3.037E-01 | 3.132E-01 | | | 042 |
| 3.000E&00 | 1.6496E&00 | 1.490E&00 | | 043 |
| 3.584E&01 | 3.541E&01 | 3.416E&01 | 3.216E&01 | 044 |
| 2.954E&01 | 2.648E&01 | 1.798E&01 | 1.026E&01 | 045 |
| 4.802E&00 | 1.770E&00 | 5.248E-01 | 2.366E-01 | 046 |
| 2.878E-01 | 3.603E-01 | 3.543E-01 | 2.808E-01 | 047 |
| 1.863E-01 | 1.138E-01 | 8.365E-02 | 9.024E-02 | 048 |
| 1.107E-01 | 1.209E-01 | | | 049 |
| 3.500E&00 | 2.1210E&00 | 1.935E&00 | | 050 |
| 8.223E&01 | 8.093E&01 | 7.715E&01 | 7.120E&01 | 051 |
| 6.359E&01 | 5.490E&01 | 3.252E&01 | 1.500E&01 | 052 |
| 5.143E&00 | 1.370E&00 | 6.305E-01 | 7.022E-01 | 053 |
| 7.068E-01 | 5.645E-01 | 3.948E-01 | 2.689E-01 | 054 |
| 2.111E-01 | 2.441E-01 | 3.683E-01 | 5.594E-01 | 055 |
| 7.342E-01 | 8.051E-01 | | | 056 |
| 4.000E&00 | 2.5920E&00 | 2.377E&00 | | 057 |
| 1.696E&02 | 1.662E&02 | 1.561E&02 | 1.406E&02 | 058 |
| 1.213E&02 | 9.989E&01 | 4.927E&01 | 1.649E&01 | 059 |
| 3.491E&00 | 1.499E&00 | 2.072E&00 | 1.830E&00 | 060 |
| 9.556E-01 | 3.545E-01 | 3.140E-01 | 5.459E-01 | 061 |
| 6.796E-01 | 6.018E-01 | 4.585E-01 | 4.231E-01 | 062 |
| 4.991E-01 | 5.515E-01 | | | 063 |
| 4.500E&00 | 2.9589E&00 | 2.717E&00 | | 064 |

TABLE X. (CONT)

| | | | | |
|---|---|---|---|---|
| 3.047E+02 | 2.968E+02 | 2.743E+02 | 2.402E+02 | 065 |
| 1.988E+02 | 1.550E+02 | 6.171E+01 | 1.455E+01 | 066 |
| 3.402E+00 | 3.770E+00 | 3.309E+00 | 1.716E+00 | 067 |
| 8.321E-01 | 6.662E-01 | 7.159E-01 | 7.508E-01 | 068 |
| 7.319E-01 | 5.760E-01 | 4.297E-01 | 5.730E-01 | 069 |
| 9.627E-01 | 1.179E+00 | | | 070 |
| 5.000E+00 | 3.3005E+00 | 3.035E+00 | | 071 |
| 5.088E+02 | 4.926E+02 | 4.467E+02 | 3.786E+02 | 072 |
| 2.987E+02 | 2.180E+02 | 6.561E+01 | 1.028E+01 | 073 |
| 7.009E+00 | 7.949E+00 | 3.759E+00 | 1.083E+00 | 074 |
| 1.363E+00 | 1.705E+00 | 9.699E-01 | 3.763E-01 | 075 |
| 7.452E-01 | 1.319E+00 | 1.296E+00 | 1.058E+00 | 076 |
| 1.178E+00 | 1.349E+00 | | | 077 |
| 5.500E+00 | 3.5201E+00 | 3.224E+00 | | 078 |
| 7.869E+02 | 7.561E+02 | 6.702E+02 | 5.459E+02 | 079 |
| 4.061E+02 | 2.730E+02 | 5.878E+01 | 1.149E+01 | 080 |
| 1.446E+01 | 8.527E+00 | 2.619E+00 | 2.202E+00 | 081 |
| 1.993E+00 | 1.284E+00 | 1.107E+00 | 1.016E+00 | 082 |
| 1.232E+00 | 1.694E+00 | 1.369E+00 | 6.398E-01 | 083 |
| 7.507E-01 | 1.106E+00 | | | 084 |
| 6.000E+00 | 3.6391E+00 | 3.325E+00 | | 085 |
| 1.119E+03 | 1.067E+03 | 9.233E+02 | 7.214E+02 | 086 |
| 5.037E+02 | 3.093E+02 | 4.628E+01 | 2.020E+01 | 087 |
| 2.213E+01 | 7.065E+00 | 2.835E+00 | 4.432E+00 | 088 |
| 2.516E+00 | 1.067E+00 | 2.050E+00 | 1.814E+00 | 089 |
| 5.302E-01 | 1.283E+00 | 2.446E+00 | 1.959E+00 | 090 |
| 1.713E+00 | 2.035E+00 | | | 091 |
| 6.500E+00 | 3.7181E+00 | 3.372E+00 | | 092 |
| 1.563E+03 | 1.476E+03 | 1.238E+03 | 9.146E+02 | 093 |
| 5.858E+02 | 3.170E+02 | 3.622E+01 | 4.026E+01 | 094 |
| 2.253E+01 | 5.277E+00 | 6.796E+00 | 3.669E+00 | 095 |
| 2.104E+00 | 2.251E+00 | 1.433E+00 | 1.748E+00 | 096 |

TABLE X. (CONT)

| | | | | |
|---|---|---|---|---|
| 1.509E&00 | 2.249E&00 | 3.671E&00 | 2.000E&00 | 097 |
| 4.161E-01 | 6.168E-01 | | | 098 |
| 7.000E&00 | 3.6079E&00 | 3.247E&00 | | 099 |
| 1.954E&03 | 1.826E&03 | 1.486E&03 | 1.039E&03 | 100 |
| 6.112E&02 | 2.920E&02 | 4.102E&01 | 5.736E&01 | 101 |
| 1.846E&01 | 7.645E&00 | 9.499E&00 | 3.248E&00 | 102 |
| 2.876E&00 | 3.547E&00 | 1.380E&00 | 2.786E&00 | 103 |
| 2.802E&00 | 7.054E-01 | 3.126E&00 | 3.432E&00 | 104 |
| 1.742E&00 | 2.046E&00 | | | 105 |
| 7.500E&00 | 3.5477E&00 | 3.158E&00 | | 106 |
| 2.500E&03 | 2.306E&03 | 1.799E&03 | 1.165E&03 | 107 |
| 6.026E&02 | 2.362E&02 | 6.812E&01 | 7.033E&01 | 108 |
| 1.207E&01 | 1.662E&01 | 6.733E&00 | 4.507E&00 | 109 |
| 4.001E&00 | 2.092E&00 | 2.917E&00 | 1.660E&00 | 110 |
| 2.798E&00 | 1.678E&00 | 5.165E&00 | 5.501E&00 | 111 |
| 7.160E-01 | 1.407E-01 | | | 112 |
| 8.000E&00 | 3.3134E&00 | 2.903E&00 | | 113 |
| 2.859E&03 | 2.601E&03 | 1.943E&03 | 1.160E&03 | 114 |
| 5.259E&02 | 1.751E&02 | 1.102E&02 | 6.360E&01 | 115 |
| 1.652E&01 | 1.992E&01 | 5.795E&00 | 6.143E&00 | 116 |
| 4.552E&00 | 2.425E&00 | 4.343E&00 | 1.634E&00 | 117 |
| 4.952E&00 | 3.035E&00 | 2.521E&00 | 6.086E&00 | 118 |
| 1.739E&00 | 1.623E&00 | | | 119 |
| 8.500E&00 | 3.1095E&00 | 2.683E&00 | | 120 |
| 3.303E&03 | 2.057E&03 | 2.095E&03 | 1.125E&03 | 121 |
| 4.189E&02 | 1.095E&02 | 1.635E&02 | 4.831E&01 | 122 |
| 2.984E&01 | 1.745E&01 | 7.996E&00 | 7.611E&00 | 123 |
| 3.542E&00 | 4.141E&00 | 2.385E&00 | 3.532E&00 | 124 |
| 2.726E&00 | 3.568E&00 | 3.631E&00 | 9.957E&00 | 125 |
| 2.191E&00 | 1.820E-01 | | | 126 |
| 9.000E&00 | 2.8927E&00 | 2.434E&00 | | 127 |
| 3.637E&03 | 3.189E&03 | 2.109E&03 | 9.852E&02 | 128 |

TABLE X (CONT.)

| | | | | |
|---|---|---|---|---|
| 2.850E&02 | 8.563E&01 | 2.002E&02 | 3.551E&01 | 129 |
| 4.506E&01 | 1.222E&01 | 1.240E&01 | 6.293E&00 | 130 |
| 4.279E&00 | 4.764E&00 | 2.832E&00 | 5.451E&00 | 131 |
| 2.287E&00 | 8.475E&00 | 1.831E&00 | 9.427E&00 | 132 |
| 3.105E&00 | 2.411E&00 | | | 133 |
| 9.500E&00 | 2.5915E&00 | 2.128E&00 | | 134 |
| 3.736E&03 | 3.213E&03 | 1.987E&03 | 7.945E&02 | 135 |
| 1.618E&02 | 8.324E&01 | 2.126E&02 | 3.383E&01 | 136 |
| 5.154E&01 | 1.069E&01 | 1.675E&01 | 4.775E&00 | 137 |
| 7.244E&00 | 3.804E&00 | 3.682E&00 | 4.160E&00 | 138 |
| 3.179E&00 | 6.542E&00 | 1.713E&00 | 1.287E&01 | 139 |
| 4.698E&00 | 7.594E-01 | | | 140 |
| 1.000E&01 | 2.4504E&00 | 1.954E&00 | | 141 |
| 4.106E&03 | 3.429E&03 | 1.913E&03 | 5.897E&02 | 142 |
| 6.616E&01 | 1.503E&02 | 1.857E&02 | 6.612E&01 | 143 |
| 3.797E&01 | 2.404E&01 | 1.008E&01 | 6.627E&00 | 144 |
| 5.398E&00 | 3.466E&00 | 4.704E&00 | 4.887E&00 | 145 |
| 4.443E&00 | 8.197E&00 | 4.898E&00 | 1.087E&01 | 146 |
| 6.851E&00 | 6.558E&00 | | | 147 |
| 1.100E&01 | 2.0873E&00 | 1.564E&00 | | 148 |
| 4.296E&03 | 3.393E&03 | 1.528E&03 | 2.262E&02 | 149 |
| 4.213E&01 | 3.228E&02 | 8.616E&01 | 1.280E&02 | 150 |
| 2.287E&01 | 3.049E&01 | 1.531E&01 | 6.704E&00 | 151 |
| 6.362E&00 | 5.252E&00 | 3.289E&00 | 3.635E&00 | 152 |
| 1.018E&01 | 2.359E&00 | 1.145E&01 | 9.088E&00 | 153 |
| 1.222E&01 | 1.342E&01 | | | 154 |
| 1.200E&01 | 1.9056E&00 | 1.357E&00 | | 155 |
| 4.801E&03 | 3.639E&03 | 1.413E&03 | 1.620E&02 | 156 |
| 1.925E&02 | 4.064E&02 | 6.552E&01 | 1.008E&02 | 157 |
| 6.557E&01 | 1.286E&01 | 2.007E&01 | 1.282E&01 | 158 |
| 4.979E&00 | 3.490E&00 | 4.942E&00 | 6.075E&00 | 159 |
| 5.765E&00 | 5.871E&00 | 1.465E&01 | 5.462E&00 | 160 |

TABLE X. (CONT.)

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.810E&01 | 1.072E&01 | | | | | 161 |
| 1.300E&01 | 1.9485E&00 | 1.364E&00 | | | | 162 |
| 6.782E&03 | 5.103E&03 | 2.027E&03 | 4.178E&02 | | | 163 |
| 3.169E&02 | 2.855E&02 | 1.700E&02 | 4.166E&01 | | | 164 |
| 6.987E&01 | 3.993E&01 | 9.010E&00 | 1.049E&01 | | | 165 |
| 1.151E&01 | 7.049E&00 | 3.214E&00 | 2.843E&00 | | | 166 |
| 4.143E&00 | 1.785E&01 | 1.071E&01 | 2.160E&00 | | | 167 |
| 2.449E&01 | 2.524E&01 | | | | | 168 |
| 1.400E&01 | 2.1700E&00 | 1.541E&00 | | | | 169 |
| 1.144E&04 | 8.576E&03 | 3.455E&03 | 7.547E&02 | | | 170 |
| 2.617E&02 | 7.443E&01 | 2.396E&02 | 9.219E&01 | | | 171 |
| 3.024E&01 | [illegible] | 2.930E&01 | 1.143E&01 | | | 172 |
| 4.276E&00 | [illegible] | 5.657E&00 | 6.674E&00 | | | 173 |
| 1.302E&01 | 1.740E&01 | 4.613E&00 | 2.566E&00 | | | 174 |
| 3.101E&01 | 3.443E&01 | | | | | 175 |
| 1.500E&01 | 2.4165E&00 | 1.757E&00 | | | | 176 |
| 1.863E&04 | 1.374E&04 | 5.229E&03 | 8.972E&02 | | | 177 |
| 8.137E&01 | 1.048E&01 | 1.430E&01 | 1.524E&01 | | | 178 |
| 6.992E&01 | 2.349E&01 | 1.504E&01 | 1.614E&01 | | | 179 |
| 1.391E&01 | 1.022E&01 | 7.038E&00 | 3.340E&00 | | | 180 |
| 7.318E&00 | 4.449E&00 | 7.815E&00 | 7.673E&00 | | | 181 |
| 3.629E&01 | 4.067E&01 | | | | | 182 |
| 0.00 | 4.00 | 8.00 | 12.00 | 16.00 | 20.00 | 183 |
| 30.00 | 40.00 | 50.00 | 60.00 | 70.00 | 80.00 | 184 |
| 90.00 | 100.00 | 110.00 | 120.00 | 130.00 | 140.00 | 185 |
| 150.00 | 160.00 | 170.00 | 180.00 | | | 186 |

TABLE XI. RRA-45 SAMPLE PROBLEM PRINTED OUTPUT DATA

RADIATION RESEARCH ASSOCIATES , FORT WORTH , TEXAS

MACROSCOPIC MIE CROSS SECTIONS     PROCEDURE RRA-45

PROBLEM NUMBER     2

| SCATTERING ANGLE | PHASE FUNCTION | DIFFERENTIAL PROBABILITY | CUMULATIVE PROBABILITY |
|---|---|---|---|
| 0.00 | 8.199e-04 | 3.851e+00 | 0.000e+00 |
| 4.00 | 7.428e-04 | 3.486e+00 | 5.507e-02 |
| 8.00 | 5.587e-04 | 2.624e+00 | 1.917e-01 |
| 12.00 | 3.622e-04 | 1.701e+00 | 3.512e-01 |
| 16.00 | 2.161e-04 | 1.015e+00 | 4.901e-01 |
| 20.00 | 1.279e-04 | 6.009e-01 | 5.959e-01 |
| 30.00 | 4.339e-05 | 2.038e-01 | 7.599e-01 |
| 40.00 | 1.946e-05 | 9.139e-02 | 8.463e-01 |
| 50.00 | 9.587e-06 | 4.502e-02 | 8.964e-01 |
| 60.00 | 5.243e-06 | 2.462e-02 | 9.265e-01 |
| 70.00 | 3.138e-06 | 1.474e-02 | 9.455e-01 |
| 80.00 | 2.000e-06 | 9.391e-03 | 9.580e-01 |
| 90.00 | 1.441e-06 | 6.769e-03 | 9.667e-01 |
| 100.00 | 1.113e-06 | 5.226e-03 | 9.732e-01 |
| 110.00 | 9.559e-07 | 4.489e-03 | 9.783e-01 |
| 120.00 | 9.411e-07 | 4.420e-03 | 9.827e-01 |
| 130.00 | 1.025e-06 | 4.816e-03 | 9.868e-01 |
| 140.00 | 1.142e-06 | 5.362e-03 | 9.907e-01 |
| 150.00 | 1.388e-06 | 6.520e-03 | 9.944e-01 |
| 160.00 | 1.692e-06 | 7.945e-03 | 9.978e-01 |
| 170.00 | 1.004e-06 | 4.716e-03 | 9.996e-01 |
| 180.00 | 9.778e-07 | 4.592e-03 | 1.000e+00 |

MACROSCOPIC EXTINCTION CROSS SECTION = 2.411e-04

MACROSCOPIC SCATTERING CROSS SECTION = 2.129e-04

CROSS SECTION FROM PHASE FUNCTION = 2.134e-04

AVERAGE COSINE = 8.516e-01

TABLE XI. (CONT.)

| CUMULATIVE PROBABILITY | CORRESPONDING COSINE VALUE |
|---|---|
| 4.000E-02 | 9.987E-01 |
| 8.000E-02 | 9.966E-01 |
| 1.200E-01 | 9.947E-01 |
| 1.600E-01 | 9.924E-01 |
| 2.000E-01 | 9.898E-01 |
| 2.400E-01 | 9.871E-01 |
| 2.800E-01 | 9.842E-01 |
| 3.200E-01 | 9.809E-01 |
| 3.600E-01 | 9.772E-01 |
| 4.000E-01 | 9.728E-01 |
| 4.400E-01 | 9.679E-01 |
| 4.800E-01 | 9.627E-01 |
| 5.200E-01 | 9.556E-01 |
| 5.600E-01 | 9.475E-01 |
| 6.000E-01 | 9.382E-01 |
| 6.400E-01 | 9.226E-01 |
| 6.800E-01 | 9.054E-01 |
| 7.200E-01 | 8.865E-01 |
| 7.600E-01 | 8.659E-01 |
| 8.000E-01 | 8.227E-01 |
| 8.400E-01 | 7.742E-01 |
| 8.800E-01 | 6.854E-01 |
| 9.200E-01 | 5.321E-01 |
| 9.600E-01 | 1.333E-01 |
| 1.000E+00 | -1.000E+00 |

TABLE XII. RRA-45 SAMPLE PROBLEM PUNCHED OUTPUT DATA

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.000E+00 | 9.976E-01 | 9.903E-01 | 9.781E-01 | 9.613E-01 | 9.397E-01 | 2 | 1 | LITE |
| 8.660E-01 | 7.660E-01 | 6.428E-01 | 5.000E-01 | 3.420E-01 | 1.736E-01 | 2 | 2 | LITE |
| 2.268E-07 | -1.736E-01 | -3.420E-01 | -5.000E-01 | -6.428E-01 | -7.660E-01 | 2 | 3 | LITE |
| -8.660E-01 | -9.397E-01 | -9.848E-01 | -1.000E+00 | 0.000E+00 | 0.000E+00 | 2 | 4 | LITE |
| 3.851E+00 | 3.488E+00 | 2.624E+00 | 1.701E+00 | 1.015E+00 | 6.009E-01 | 2 | 1 | LITE |
| 2.038E-01 | 9.139E-02 | 4.502E-02 | 2.462E-02 | 1.474E-02 | 9.391E-03 | 2 | 2 | LITE |
| 6.769E-03 | 5.226E-03 | 4.489E-03 | 4.420E-03 | 4.816E-03 | 5.362E-03 | 2 | 3 | LITE |
| 6.520E-03 | 7.945E-03 | 4.716E-03 | 4.592E-03 | 0.000E+00 | 0.000E+00 | 2 | 4 | LITE |
| 9.987E-01 | 9.966E-01 | 9.947E-01 | 9.924E-01 | 9.898E-01 | 9.871E-01 | 2 | 1 | LITE |
| 9.842E-01 | 9.809E-01 | 9.772E-01 | 9.728E-01 | 9.679E-01 | 9.627E-01 | 2 | 2 | LITE |
| 9.556E-01 | 9.475E-01 | 9.382E-01 | 9.226E-01 | 9.054E-01 | 8.865E-01 | 2 | 3 | LITE |
| 8.659E-01 | 8.227E-01 | 7.742E-01 | 6.854E-01 | 5.321E-01 | 1.333E-01 | 2 | 4 | LITE |
| -1.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2 | 5 | LITE |

```
BEGIN                                                               00001000   0000
                                                        START OF SEGMENT ********** 0002
FILE IN CARD 0(2,10);                                               00002000   0000
FILE OUT PUNCH 0(2,10);                                             00003000   0005
FILE OUT PRINT 4(2,15);                                             00004000   0010
FILE XXXXXX 2(2,15);                                                00005000   0015
FILE TAPE1 2(2,15);                                                 00006000   0020
FILE TAPE2 2(2,15);                                                 00007000   0025
FILE TAPE3 2(2,15);                                                 00008000   0030
FILE TAPE4 2(2,15);                                                 00009000   0035
FILE TAPE5 2(2,15);                                                 00010000   0040
FILE TAPE6 2(2,15);                                                 00011000   0045
FILE TAPE7 2(2,15);                                                 00012000   0050
FILE TAPE8 2(2,15);                                                 00013000   0055
FILE TAPE9 2(2,15);                                                 00014000   0060
FILE TAPE10 2(2,15);                                                00015000   0065
FILE TAPE11 2(2,15);                                                00016000   0070
FILE TAPE12 2(2,15);                                                00017000   0075
FILE TAPE13 2(2,15);                                                00018000   0080
FILE TAPE14 2(2,15);                                                00019000   0085
FILE TAPE15 2(2,15);                                                00020000   0090
FILE TAPE16 2(2,15);                                                00021000   0095
SWITCH FILE FILES←XXXXXX,TAPE1,TAPE2,TAPE3,TAPE4,TAPE5,TAPE6,TAPE7, 00022000   0100
   TAPE8,TAPE9,TAPE10,TAPE11,TAPE12,TAPE13,TAPE14,TAPE15,TAPE16;    00023000   0112
LABEL  FINIS;                                                       00024000   0123
REAL ARRAY  DATA[0:63,0:511];    COMMENT USED WITH DATA STATEMENTS ONLY;  00025000   0123
REAL Q,XPR;    INTEGER X;                                           00026000   0125
FORMAT F(///////"STOP / PAUSE  NO. ",I5), DKTL(2560);               00027000   0125
                                                        START OF SEGMENT ********** 0003
                                                        0003 IS 0017 LONG, NEXT SEG 0002
REAL PROCEDURE INT(ARG1);        VALUE ARG1;        REAL ARG1;      00028000   0125
   INT←SIGN(ARG1)×ENTIER(ABS(ARG1));                                00029000   0125
```

```
REAL PROCEOURE TANH(ARG1);         VALUE ARG1;          REAL ARG1;              00030000    0133
   TANH←((0•EXP(ARG1×2))−1)/(0+1));                                              00031000    0133
REAL PROCEOURE MAX(ARG1,ARG2);     VALUE ARG1,ARG2;     REAL ARG1,ARG2;         00032000    0140
   MAX←IF ARG1≥ARG2 THEN ARG1 ELSE ARG2;                                        00033000    0140
REAL PROCEOURE MIN(ARG1,ARG2);     VALUE ARG1,ARG2;     REAL ARG1,ARG2;         0003A000    0145
   MIN←IF ARG1≤ARG2 THEN ARG1 ELSE ARG2;                                        00035000    0145
REAL PROCEOURE DIM(AFG1,ARG2);     VALUE ARG1,ARG2;     REAL ARG1,ARG2;         00036000    0150
   DIM←MAX(ARG1−ARG2,0);                                                        00037000    0150
REAL PROCEDURE TSIGN(ARG1,ARG2);   VALUE ARG1,ARG2;     REAL ARG1,ARG2;         00038000    015A
   TSIGN←SIGN(ARG2)×ABS(ARG1);                                                  00039000    0154
REAL PROCEOURE LOG(ARG1);          VALUE ARG1;          REAL ARG1;              00040000    0159
   LOG←LN(ARG1)/2.302585092981;                                                 00041000    0159
PROCEDURE ERROR(ARG1);             VALUE ARG1;          REAL ARG1;              000A2000    0165
BEGIN WRITE(PRINT,E,ARG1); GO TO FINIS END;                                     0004300     0165
PROCEOURE SHGRATER(JKEEP,SVH,SVF,SVAR,JM);                                      0004A000    0175
  VALUE JKEEP,JM;                                                               000A5000    0175
  INTEGER JKEEP,JM;                                                             000A6000    0175
  REAL ARRAY SVH[0],SVF[0],SVAR[0];                                             00047000    0175
BEGIN                                                                           00048000    0175
OWN INTEGER JI;                                                                 00049000    0175
                                                              START OF SEGMENT ********** 0004
OWN REAL JOELTA,JAC,JRC,JCC;                                                    00050000    0000
JI←JM;                                                                          00051000    0000
DO BEGIN                                                                        00052000    0000
  JOELTA←(SVH[JI−1]↑2)×SVH[JI]−(SVH[JI]↑2)×SVH[JI−1]+(SVH[JI]↑2)×SVH[           00053000    0000
   JI−2]−(SVH[JI−2]↑2)×SVH[JI]+(SVH[JI−2]↑2)×SVH[JI−1]−(SVH[JI−1]↑2)×SVH        00054000    0006
[JI−2];                                                                         00055000    0015
  JAC←(SVF[JI−1]×SVH[JI]−SVF[JI]×SVH[JI−1]+SVF[JI]×SVH[JI−2]−SVF[               00056000    0017
   JI−2]×SVH[JI]+SVF[JI−2]×SVH[JI−1]−SVF[JI−1]×SVH[JI−2])/JOELTA;               00057000    0022
  JRC←((SVH[JI−1]↑2)×SVF[JI]−(SVH[JI]↑2)×SVF[JI−1]+(SVH[JI]↑2)×SVF[             00058000    0030
   JI−2]−(SVH[JI−2]↑2)×SVF[JI]+(SVH[JI−2]↑2)×SVF[JI−1]−(SVH[JI−1]↑2)×SVF        00059000    0036
[JI−2])/JOELTA;                                                                 00060000    0045
```

```
  JCC←(SVF[JI-2]×((SVH[JI-1]*2)×SVH[JI]-(SVH[JI]*2)×SVH[JI-1])+SVF[          0047
   JI-1]×((SVH[JI]*2)×SVH[JI-2]-(SVH[JI-2]*2)×SVH[JI])+SVF[JI]×((SVH[          0053
   JI-2]*2)×SVH[JI-1]-(SVH[JI-1]*2)×SVH[JI-2]))/JDELTA;                        0060
  SVAR[JI]←(JAC/3)×((SVH[JI]*3)-(SVH[JI-2]*3))+(JBC/2)×((SVH[JI]*2)-(SVH       0067
[JI-2]*2))+JCC×(SVH[JI]-SVH[JI-2]);                                            0074
  END UNTIL (JI←(JI+2))>JKEEP;                                                 0079
 END;                                                                          0082
                                                  0004 IS 0083 LONG, NEXT SEG 0002
PROCEDURE SHGRATRE(JKEEP,SVH,SVF,SVAR);                                        0175
  VALUE JKEEP;                                                                 0175
  INTEGER JKEEP;                                                               0175
  REAL ARRAY SVH[0],SVF[0],SVAR[0];                                            0175
BEGIN                                                                          0175
OWN INTEGER JI;                                                                0175
                                                  START OF SEGMENT ********** 0005
OWN REAL JBB,JAA;                                                              0000
JI←1;                                                                          0000
DO BEGIN                                                                       0000
  JBB←LN(SVF[JI]/SVF[JI+1])/(SVH[JI]-SVH[JI+1]);                               0000
  JAA←SVF[JI]/EXP(JBB×SVH[JI]);                                                0005
  SVAR[JI+1]←-(JAA/(JBB×JBB+1))×(EXP(JBB×SVH[JI])×(JBB×SIN(SVH[JI])-COS(      0008
   SVH[JI]))-EXP(JBB×SVH[JI+1])×(JBB×SIN(SVH[JI+1])-COS(SVH[JI+1])));          0015
  END UNTIL (JI←(JI+1))>JKEEP;                                                 0024
 END;                                                                          0027
                                                  0005 IS 0036 LONG, NEXT SEG 0002
PROCEDURE MAINPRO;                                                             0175
BEGIN                                                                          0175
OWN REAL ARRAY SVX[0:100],SVEXKROS[0:100],SVSCKROS[0:100],                     0175
                                                  START OF SEGMENT ********** 000A
 SVPHASE[0:100,0:100],SVTHETA[0:100],SVR[0:100],SVENR[0:100],                  0007
 SVH[0:100],SVF[0:100],SVBPHASE[0:100],SVCTHETA[0:100],                        0016
 SVSTHETA[0:100],SVP[0:100],SVTHET[0:50],SVCTHET[0:50],                        0028
```

```
 SVOPROB[0:100],SVPR[0:100],SVANGLE[0:100],SVAR[0:100];                00089000    0038
OWN INTEGER OX1;                                                       00090000    0048
OWN INTEGER JNRROB,JNTHETA,JNEXES,JNTARE,JNGRATE,JNA,JNB,JI,JKL,       00091000    0048
 JIPROB,JNROIV,JK,JJ,JM,JNX,JKEER,JNT,JNSTART,JL,JNK;                  00092000    0048
OWN REAL JXMIN,JXMAX,JMFL,JCHOOSE,JORTION,JOECIDE,JNAVLGH,JCAY,JA,     00093000    0048
 JALPHA,JP,JGAMMA,JCONST,JXPMAX,JRPMAX,JREXTK,JBSCAK,JRX,JAVGCOS,      00094000    0048
 JPMAX,JRRX1,JBRX2,JRE,JANPDIV,JORE,JFRAC;                             00095000    0048
COMMENT  THE FOLLOWING PROCEDURES ARE USED:  SRGRATER,SRGRATRE;        00096000    0048
FORMAT FL50(S18),                                                      00097000    0048
                                                          START OF SEGMENT ********** 0007
FL60(R18.12,16),                                                       00098000    0048
FL70(8R10.2),                                                          00099000    0048
FL80(R18.10,2R18.10),                                                  00100000    0048
FL90(4P15.10),                                                         00101000    0048
FL120(4R18.8),                                                         00102000    0048
FL130(R18.12,3R18.8),                                                  00103000    0048
FL140(5R12.10),                                                        00104000    0048
FL65(" "//X18,"RADIATION RESEARCH ASSOCIATES , FORT WORTH , TEXAS"),   00105000    0048
FL75(/X16,"MACROSCOPIC MIE CROSS SECTIONS     PROCEDURE RRA-45"),      00106000    0048
FL85(/X31,"PROBLEM NUMBER ",I5),                                       00107000    0048
FL95(/X7,"SCATTERING",X12,"PHASE",X12,"DIFFERENTIAL",X10,"CUMULATIVE"),  00108000    0048
FL165(X9,"ANGLE",X14,"FUNCTION",X10,"PROBABILITY",X11,"PROBABILITY"),  00109000    0048
FL175(////),                                                           00110000    0048
FL145(" "/////X5,"CUMULATIVE",X15,"CORRESPONDING"),                    00111000    0048
FL185(X5,"PROBABILITY",X14,"COSINE VALUE"/);                           00112000    0048
                                                          0007 IS 0136 LONG, NEXT SEG 0006
COMMENT  FORMAT FL110 IS MISSING;                                      00113000    0048
COMMENT  FORMAT FL55 IS MISSING;                                       00114000    0048
COMMENT  FORMAT FL105 IS MISSING;                                      00115000    0048
COMMENT  FORMAT FL115 IS MISSING;                                      00116000    0048
COMMENT  FORMAT FL125 IS MISSING;                                      00117000    0048
COMMENT  FORMAT FL195 IS MISSING;                                      00118000    0048
```

```
COMMENT  FORMAT FL135 IS MISSING;                                       00119000    0048
COMMENT  FORMAT FL155 IS MISSING;                                       00120000    004B
LIST LIST1(JNPROB,JNTHETA,JNEXES,JNTAPE,JNGRATE);                       00121000    0048
LIST LIST2(JXMIN,JXMAX);                                                00122000    0058
LIST LIST3(SVX[1],SVEXKROS[1],SVSCKROS[1]);                             00123000    0065
LIST LIST4(FOR DX1+1 STEP 1 UNTIL JNTHETA DO SVPHASE[DX1,1]);           00124000    0074
LIST LIST5(SVX[J1],SVEXKROS[J1],SVSCKROS[J1]);                          00125000    0084
LIST LIST6(FOR DX1+1 STEP 1 UNTIL JNTHETA DO SVPHASE[DX1,J1]);          00126000    0093
LIST LIST7(JNFL);                                                       00127000    0103
LIST LIST8(FOR DX1+1 STEP 1 UNTIL JNTHETA DO SVTHETA[DX1]);             00128000    0108
LIST LIST9(JCHOOSE,JOPTION,JDECIDE);                                    00129000    0117
LIST LIST10(JNAVLGH,J1PROB);                                            00130000    0125
LIST LIST11(JNPOINT);                                                   00131000    0132
LIST LIST12(JA,JALPHA,JP,JGAMMA);                                       00132000    0137
LIST LIST13(JCONST,JXPMAX,JA,JALPHA);                                   00133000    0146
LIST LIST14(FOR DX1+1 STEP 1 UNTIL JNEXES DO SVENR[DX1]);               00134000    0155
LIST LIST15(SVCTHETA[J1],SVCTHETA[J1+1],SVCTHETA[J1+2],SVCTHETA[J1+3],SV 00135000    0164
CTHETA[J1+4],SVCTHETA[J1+5],J1PROB,JNK);                                00136000    0173
LIST LIST16(SVOPROB[J1],SVOPROB[J1+1],SVOPROB[J1+2],SVOPROB[J1+3],SVOPRO 00137000    0182
B[J1+4],SVOPROB[J1+5],J1PROB,JNK);                                      00138000    0191
LIST LIST17(SVCTHET[J1],SVCTHET[J1+1],SVCTHET[J1+2],SVCTHET[J1+3],SVCTHE 00139000    0200
T[J1+4],SVCTHET[J1+5],J1PROB,JNK);                                      00140000    0209
LIST LIST18(J1PROB);                                                    00141000    0218
LIST LIST19(SVTHETA[J1],SVBPHASE[J1],SVOPROB[J1],SVP[J1]);              00142000    0223
LIST LIST20(JBEXTK);                                                    00143000    0233
LIST LIST21(JBSCAK);                                                    00144000    0238
LIST LIST22(JPMAX);                                                     00145000    0243
LIST LIST23(JAVGCOS);                                                   00146000    0248
LIST LIST24(SVPP[J1],SVCTHET[J1]);                                      00147000    0253
BEGIN                                                                   00148000    0260
LABEL L126,L101,L107,L104,L109,L111,L113,L118,L37,L13,L6,L7,L9,L14,     00149000    0260
                                                          START OF SEGMENT ********** 000B
```

```
L12,L11,L16,L17,L22,L42,L67,L72,L73,L77,L202,L208,L81,L89,L87,L88,          00150000   0000
L26;                                                                        00151000   0000
COMMENT  MACROSCOPIC MIE ANALYSIS;;                                         00152000   0000
FORMAT                                                                      00153000   0000
FL110(3R6.2),                                                               00154000   0060
                                                                    START OF SEGMENT ********** 0009
FL55(S,,6E10.3,X4,I4,X1,I4,X3,"LITE"),                                      00155000   0000
FL105(X8,R7.2,S1 3F21.3),                                                   00156000   0000
FL115(/X2,"MACROSCOPIC EXTINCTION CROSS SECTION = ",S1,E10.3),              00157000   0000
FL125(/X2,"MACROSCOPIC SCATTERING CROSS SECTION = ",S1,E10.3),              00158000   0000
FL135(/X2,"AVERAGE COSINE",X22," = ",S1,E10.3),                             00159000   0000
FL155(X5,S1,E10.3,X16,S1,E10.3),                                            00160000   0000
FL195(/X2,"CROSS SECTION FROM PHASE FUNCTION = ",X3,S1,E10.3);              00161000   0000
                                                                    0009 IS 0085 LONG, NEXT SEG 0008
READ(CARD,FL50,LIST1)[FINIS];                                               00162000   0000
JN4+JNTHETA DIV 4;                                                          00163000   0005
JNB+JNA×4;                                                                  00164000   0006
IF JNTHETA=JNB THEN GO TO L126;                                             00165000   0007
JN4+JNA+1;                                                                  00166000   0008
L126: IF JNTAPE≠0 THEN GO TO L101;                                          00167000   0010
READ(CARD,FL90,LIST2)[FINIS];                                               00168000   0011
L107: READ(TAPE9,FL80,LIST3)[FINIS];                                        00169000   0016
IF SVX[1]≥JXMIN THEN GO TO L104;                                            00170000   0022
JI+1;                                                                       00171000   0023
DO BEGIN                                                                    00172000   0024
  READ(TAPE9,FL80)[FINIS];                                                  00173000   0024
  END UNTIL (JI+(JI+1))>JNA;                                                00174000   0029
GO TO L107;                                                                 00175000   0031
L104: READ(TAPE9,FL90,LIST4)[FINIS];                                        00176000   0036
JI+2;                                                                       00177000   0041
DO BEGIN                                                                    00178000   0041
  READ(TAPE9,FL80,LIST5)[FINIS];                                            00179000   0041
```

```
  READ(TAPE9,FL90,LIST6)[FINIS];                                   0046
  END UNTIL (JI←(JI+1))>JNEXES;                                    0051
IF SV[JNEXES]≥JXMAX THEN GO TO L111;                               0054
L109: READ(TAPE9,FL80,LIST7)[FINIS];                               0055
IF JNFL≥JXMAX THEN GO TO L113;                                     0061
JI←1;                                                              0062
DO BEGIN                                                           0063
  READ(TAPE9,FL80)[FINIS];                                         0063
  END UNTIL (JI←(JI+1))>JNA;                                       0067
GO TO L109;                                                        0070
L113: JI←1;                                                        0076
DO BEGIN                                                           0076
  READ(TAPE9,FL80)(FINIS);                                         0076
  END UNTIL (JI←(JI+1))>JNA;                                       0081
L111: READ(TAPE9,FL70,LIST8)(FINIS);                               0083
GO TO L118;                                                        0089
L101: JI←1;                                                        0092
DO BEGIN                                                           0092
  READ(CARD,FL80,LIST5)[FINIS];                                    0092
  READ(CARD,FL90,LIST6)[FINIS];                                    0097
  END UNTIL (JI←(JI+1))>JNEXES;                                    0102
READ(CARD,FL70,LIST8)[FINIS];                                      0105
L118: JI←1;                                                        0110
DO BEGIN                                                           0110
  SVANGLE[JI]←SVTHETA[JI]×.01745329 END UNTIL (JI←(JI+1))>JNTHETA; 0110
JNL←1;                                                             0115
DO BEGIN                                                           0115
  READ(CARD,FL110,LIST9)[FINIS];                                   0115
  READ(CARD,FL60,LIST10)(FINIS);                                   0120
  READ(CARD,FL50,LIST11)[FINIS];                                   0125
  JI←1;                                                            0130
  DO BEGIN                                                         0131
```

```
  SVR[JI]←(JWAVLGH×SVX[JI])/6.2832 END UNTIL (JI←(JI+1))>JNEXES;      00212000   0131
JCAY←(6.2832/JWAVLGH)×((10)*4);                                        00213000   0136
IF JOPTION=0 THEN GO TO L13;                                           00214000   0139
IF JCHOOSE≠0 THEN GO TO L6;                                            00215000   0140
READ(CARD,FL120,LIST12)[FIN13];                                        00216000   0141
GO TO L7;                                                              00217000   0146
L6: READ(CARD,FL130,LIST13)[FINIS];                                    00218000   0156
GO TO L9;                                                              00219000   0161
L7: JK←1;                                                              00220000   0163
DO BEGIN                                                               00221000   0163
  SVENR[JK]←JA×((SVR[JK])+JALPHA)×EXP(−JR×(SVR[JK])+JGAMMA) END UNTIL  00222000   0163
 (JK←(JK+1))>JNEXES;                                                   00223000   0175
GO TO L14;                                                             00224000   0177
L9: JRPMAX←(JWAVLGH×JXPMAX)/6.2832;                                    00225000   0182
JK←1;                                                                  00226000   0183
DO BEGIN                                                               00227000   0184
  IF SVR[JK]>JRPMAX THEN GO TO L11;                                    00228000   0184
  SVENR[JK]←JCONST;                                                    00229000   0186
  GO TO L12;                                                           00230000   0187
  L11: SVENR[JK]←JA×((SVR[JK])+JALPHA);                                00231000   0189
  L12: END UNTIL (JK←(JK+1))>JNEXES;                                   00232000   0194
GO TO L14;                                                             00233000   0197
L13: READ(CARD,FL140,LIST14)[FINIS];                                   00234000   0199
L14: JJ←1;                                                             00235000   0204
DO BEGIN                                                               00236000   0204
  SVRPHASE[JJ]←0;                                                      00237000   0204
  SVP[JJ]←0 END UNTIL (JJ←(JJ+1))>JNTHETA;                             00238000   0206
JREXTK←0;                                                              00239000   0209
JPSCAK←0;                                                              00240000   0210
JM←3;                                                                  00241000   0211
JNX←JNEXES DIV 2;                                                      00242000   0211
JNX←JNX×2;                                                             00243000   0213
```

```
IF JNEXES>JNX THEN GO TO L16;                                              0214
JKEEP+JNEXES-1;                                                            0215
GO TO L17;                                                                 0218
L16: JKEEP+JNEXES;                                                         0219
L17: J1+1;                                                                 0219
DO BEGIN                                                                   0220
  SVH[J1]+SVR[J1] END UNTIL (J1+(J1+1))>JNEXES;                            0220
JJ+1;                                                                      0224
DO BEGIN                                                                   0225
  J1+1;                                                                    0225
  DO BEGIN                                                                 0226
    SVF[J1]+(SVPHASE[JJ,J1]×SVENR[J1])/(JCAY×JCAY) END UNTIL (J1+(         0228
   J1+1))>JNEXES;                                                          0230
  SRGNATER(JKEEP,SVH,SVF,SVAR,JM);                                         0232
  J1+3;                                                                    0235
  DO BEGIN                                                                 0236
    SVRPHASE[JJ]+SVAR[J1]+SVRPHASE[JJ] END UNTIL (J1+(J1+2))>JKEEP;        0236
  IF JNEXES≤JKEEP THEN GO TO L22;                                          0240
  JRX+.5×(SVF[JNEXES]+SVF[JNEXES-1])×(SVR[JNEXES]-SVR[JNEXES-1]);          0242
  SVRPHASE[JJ]+JRX+SVRPHASE[JJ];                                           0246
  L22: END UNTIL (JJ+(JJ+1))>JNTHETA;                                      0246
J1+1;                                                                      0251
DO BEGIN                                                                   0252
  SVF[J1]+(SVEXKROS[J1]×SVR[J1]×SVR[J1]×SVENR[J1])×((.1)+8) END UNTIL      0252
 (J1+(J1+1))>JNEXES;                                                       0257
SRGRATER(JKEEP,SVH,SVF,SVAR,JM);                                           0260
J1+3;                                                                      0263
DO BEGIN                                                                   0264
  JREXTK+3.1416×SVAR[J1]+JREXTK END UNTIL (J1+(J1+2))>JKEEP;               0264
IF JNEXES≤JKEEP THEN GO TO L62;                                            0268
JRX+.5×(SVF[JNEXES]+SVF[JNEXES-1])×(SVR[JNEXES]-SVR[JNEXES-1]);            0269
JREXTK+JREXTK+JRX×3.1416;                                                  0274
```

```
L62: JI+1;                                                                 00276000   0276
DO BEGIN                                                                   00277000   0276
  SVF[JI]+SVSCKROS[JI]×SVH[J[]×SVR[JI]×SVENR[JI]×((,1)+8) END UNTIL (      00278000   0276
 JI+(JI+1))>JNEXES;                                                        00279000   0282
SRGRATER(JKEEP,SVH,SVF,SVAR,JH);                                           00280000   0284
JI+3;                                                                      00281000   0286
DO REGIN                                                                   00282000   0286
  JBSCAK+3.1416×SVAR[JI]+JBSCAK END UNTIL (JI+(JI+2))>JKEEP;               00283000   0288
IF JNEXES≤JKEEP THEN GO TO L67;                                            00284000   0293
JBX+.5×(SVF[JNEXES]+SVF[JNEXES-1])×(SVR[JNEXES]-SVR[JNEXES-1]);            00285000   0294
JBSCAK+JBSCAK+JBX×3.1416;                                                  00286000   0299
L67: JI+1;                                                                 00287000   0300
DO REGIN                                                                   00288000   0301
  SVH[J[]+SVANGLE[JI];                                                     00289000   0301
  SVCTHETA[J[]+COS(SVANGLE[JI]);                                           00290000   0303
  SVSTHETA[JI]+SIN(SVANGLE[JI]) END UNTIL (JI+(JI+1))>JNTHETA;             00291000   0305
JI+1;                                                                      00292000   0310
DO REGIN                                                                   00293000   0310
  SVF[JI]+SVBPHASE[JI]×SVSTHETA[JI]×SVCTHETA[JI] END UNTIL (JI+(           00294000   0310
 JI+1))>JNTHETA;                                                           00295000   0313
JNT+JNTHETA DIV 2;                                                         00296000   0316
JNT+JNT×2;                                                                 00297000   0317
IF JNTHETA>JNT THEN GO TO L72;                                             00298000   0318
JKEEP+JNTHETA-1;                                                           00299000   0319
GO TO L73;                                                                 00300000   0321
L72: JKEEP+JNTHETA;                                                        00301000   0327
L73: JAVGCOS+0;                                                            00302000   0327
SRGRATER(JKEEP,SVH,SVF,SVAR,JH);                                           00303000   0328
JI+3;                                                                      00304000   0332
DO BEGIN                                                                   00305000   0332
  JAVGCOS+SVAR[JI]×(6.2832/JBSCAK)+JAVGCOS END UNTIL (JI+(JI+2))>          00306000   0332
 JKEEP;                                                                    00307000   0336
```

```
IF JNTHETA≤JKEEP THEN GO TO L77;                                              00308000   0337
JBX+.5×(SVF[JNTHETA]+SVF[JNTHETA-1])×(SVANGLE[JNTHETA]-SVANGLE[               00309000   0338
 JNTHETA-1]);                                                                 00310000   0341
JAVGCOS+JAVGCOS+JBX×(6.2832/JBSCAN);                                          00311000   0343
L77: IF JNGRATE=0 THEN GO TO L202;                                            00312000   0345
J1+1;                                                                         00313000   0347
DO BEGIN                                                                      00314000   0346
  SVF[J1]+SVSPHASE[J1]×6.2832 END UNTIL (J1+(J1+1))>JNTHETA;                  00315000   0348
SRGRATRE(JKEEP,SVH,SVF,SVAR);                                                 00316000   0352
J1+2;                                                                         00317000   0355
DO BEGIN                                                                      00318000   0356
  SVP[J1]+SVAR[J1]+SVP[J1-1] END UNTIL (J1+(J1+1))>JNTHETA;                   00319000   0356
JPMAX+SVP[JNTHETA];                                                           00320000   0361
GO TO L208;                                                                   00321000   0362
L202: J1+1;                                                                   00322000   0365
DO BEGIN                                                                      00323000   0365
  SVF[J1]+SVRPHASE[J1]×SVSTHETA[J1] END UNTIL (J1+(J1+1))>JNTHETA;            00324000   0365
JBRX1+.5×(SVF[2]+SVF[1])×(SVANGLE[2]-SVANGLE[1]);                             00325000   0370
JBRX2+.5×(SVF[3]+SVF[2])×(SVANGLE[3]-SVANGLE[2]);                             00326000   0374
SVP[2]+JBRX1;                                                                 00327000   0377
SVP[3]+(JBRX1+JBRX2);                                                         00328000   0379
JBRX1+JBRX1+JBRX2;                                                            00329000   0380
JBRX2+.5×(SVF[4]+SVF[3])×(SVANGLE[4]-SVANGLE[3]);                             00330000   0382
SVP[4]+(JBRX1+JBRX2);                                                         00331000   0385
JM+6;                                                                         00332000   0387
IF JNTHETA>JNT THEN GO TO L81;                                                00333000   0388
JKEEP+JNTHETA;                                                                00334000   0389
GO TO L89;                                                                    00335000   0390
L81: JKEEP+JNTHETA-1;                                                         00336000   0392
L89: SRGRATER(JKEEP,SVH,SVF,SVAR,JM);                                         00337000   0393
J1+6;                                                                         00338000   0397
DO BEGIN                                                                      00339000   0398
```

```
  SVP[JI]←SVAR[JI]+SVP[JI-2] END UNTIL (JI←(JI+2))>JKEEP;                00340000    0398
JI←6;                                                                    00341000    0403
DO BEGIN                                                                 00342000    0403
  SVP[JI]←6.2832×(SVP[JI]) END UNTIL (JI←(JI+2))>JKEEP;                  00343000    0403
IF JNTHETA>JNT THEN GO TO L87;                                           00344000    0408
JKEEP←JNTHETA-1;                                                         00345000    0409
GO TO L88;                                                               00346000    0410
L87: JKEEP←JNTHETA;                                                      00347000    0412
L88: JM←5;                                                               00348000    0412
SRGRATER(JKEEP,SVH,SVF,SVAR,JM);                                         00349000    0413
JI←5;                                                                    00350000    0417
DO BEGIN                                                                 00351000    0417
  SVP[JI]←SVAR[JI]+SVP[JI-2] END UNTIL (JI←(JI+2))>JKEEP;                00352000    0417
JI←5;                                                                    00353000    0422
DO BEGIN                                                                 00354000    0423
  SVP[JI]←6.2832×(SVP[JI]) END UNTIL (JI←(JI+2))>JKEEP;                  00355000    0423
SVP[1]←0;                                                                00356000    0427
SVP[2]←SVP[2]×6.2832;                                                    00357000    0429
SVP[3]←SVP[3]×6.2832;                                                    00358000    0431
SVP[4]←SVP[4]×6.2832;                                                    00359000    0433
JPMAX←SVP[JNTHETA];                                                      00360000    0435
L208: JI←1;                                                              00361000    0436
DO BEGIN                                                                 00362000    0436
  SVP[JI]←SVP[JI]/SVP[JNTHETA] END UNTIL (JI←(JI+1))>JNTHETA;            00363000    0436
JPF←0;                                                                   00364000    0441
JNSTART←1;                                                               00365000    0442
JANPOIV←JNPDIV;                                                          00366000    0442
JOPE←1/JANPOIV;                                                          00367000    0443
JL←1;                                                                    00368000    0444
DO BEGIN                                                                 00369000    0445
  JPF←JPE+JOPE;                                                          00370000    0445
  JK←JNSTART;                                                            00371000    0446
```

```
DO BEGIN                                                                   0447
  JNSTART←JK−1;                                                            0447
  IF JPE<SVP[JK] THEN GO TO L26;                                           0448
  END UNTIL (JK←(JK+1))>JNTHETA;                                           0450
L26: JFRAC←(JPE−SVP[JK−1])/(SVP[JK]−SVP[JK−1]);                            0452
SVTHET[JL]←SVANGLE[JK−1]+JFRAC×(SVANGLE[JK]−SVANGLE[JK−1]);                0457
END UNTIL (JL←(JL+1))>JNPOIV;                                              0461
JL←1;                                                                      0463
DO BEGIN                                                                   0464
  SVCTHET[JL]←COS(SVTHET[JL]) END UNTIL (JL←(JL+1))>JNPOIV;                0464
JI←1;                                                                      0469
DO BEGIN                                                                   0469
  SVDPROB[JI]←SVBPHASE[JI]/JBSCAK END UNTIL (JI←(JI+1))>JNTHETA;           0469
JNK←1;                                                                     0474
JI←1;                                                                      0474
DO BEGIN                                                                   0475
  WRITE(PUNCH,FL55,LIST15);                                                0475
  JNK←JNK+1 END UNTIL [JI←(JI+6)]>JNTHETA;                                 0479
JNK←1;                                                                     0482
JI←1;                                                                      0483
DO BEGIN                                                                   0484
  WRITE(PUNCH,FL55,LIST14);                                                0484
  JNK←JNK+1 END UNTIL (JI←(JI+6))>JNTHETA;                                 0488
JNK←1;                                                                     0491
JI←1;                                                                      0492
DO BEGIN                                                                   0493
  WRITE(PUNCH,FL55,LIST17);                                                0493
  JNK←JNK+1 END UNTIL [JI←(JI+6)]>JNPOIV;                                  0496
WRITE(PRINT[PAGE]);                                                        0500
WRITE(PRINT,FL65);                                                         0503
WRITE(PRINT,FL75);                                                         0507
WRITE(PRINT,FL85,LIST18);                                                  0510
```

```
 WRITE(PRINT,FL95);                                      00404000   0514
 WRITE(PRINT,FL165);                                     00405000   0517
 JI+I;                                                   00406000   0521
 DO BEGIN                                                00407000   0522
   WRITE(PRINT,FL105,LIST19);                            00408000   0522
   END UNTIL (JI+(JI+I))>JNTHETA;                        00409000   0525
 WRITE(PRINT,FL115,LIST20);                              00410000   0531
 WRITE(PRINT,FL125,LIST21);                              00411000   0535
 WRITE(PRINT,FL195,LIST22);                              00412000   0538
 WRITE(PRINT,FL135,LIST23);                              00413000   0542
 IF JOECIOE#0 THEN GO TO L37;                            00414000   0546
 WRITE(PRINT[PAGE]);                                     00415000   0547
 WRITE(PRINT,FL145);                                     00416000   0550
 WRITE(PRINT,FL185);                                     00417000   0554
 SVPP[I]+JOPE;                                           00418000   0557
 JI+2;                                                   00419000   0559
 DO BEGIN                                                00420000   0559
   SVPP[JI]+SVPP[JI-I]+JOPE END UNTIL (JI+(JI+I))>JNPOIV; 00421000   0559
 JI+I;                                                   00422000   0564
 DO BEGIN                                                00423000   0565
   WRITE(PRINT,FL155,LIST24);                            00424000   0565
   END UNTIL (JI+(JI+I))>JNPOIV;                         00425000   0569
 L37: END UNTIL (JKL+(JKL+I))>JNPROR;                    00426000   0571
ERNOR(0);                                                00427000   0574
 END END;                                                00428000   0575
                                                 0008 IS 0577 LONG, NEXT SEG 0006
                                                 0006 IS 0270 LONG, NEXT SEG 0002
COMMENT  INITIALIZING BLOCK;                             00429000   0175
 XPR+O+K+O;                                              00430000   0175
MAINPRO; FINIS:                                          00431000   0177
END.                                                     99999000   0179
                                                 0002 IS 0182 LONG, NEXT SEG 0001
```

```
    COS IS SEGMENT NUMBER 0010,PRT ADDRESS IS 0112
    EXP IS SEGMENT NUMBER 0011,PRT ADDRESS IS 0061
    LN IS SEGMENT NUMBER 0012,PRT ADDRESS IS 0067
    SIN IS SEGMENT NUMBER 0013,PRT ADDRESS IS 0111
    OUTPUT(W) IS SEGMENT NUMBER 001A,PRT ADDRESS IS 0074
    OUTPUT(C) IS SEGMENT NUMBER 0015,PRT ADDRESS IS 0071
    INPUT(W) IS SEGMENT NUMBER 0016,PRT ADDRESS IS 0252
    INPUT(C) IS SEGMENT NUMBER 0017,PRT ADDRESS IS 0251
    X TO THE I IS SEGMENT NUMBER 0018,PRT ADDRESS IS 0253
    GO TO SOLVER  IS SEGMENT NUMBER 0019,PRT ADDRESS IS 0076
    FILE CNTRL(W) IS SEGMENT NUMBER 0020,PRT ADDRESS IS 0014
    FILE CNTRL(C) IS SEGMENT NUMBER 0021,PRT ADDRESS IS 0015
    READ/WRITE IS SEGMENT NUMBER 0022,PRT ADDRESS IS 0016
NUMBER OF ERRORS DETECTED = 000.  COMPILATION TIME = 0038 SECONDS,
PRT SIZE=0173;TOTAL SEGMENT SIZE=01389 WORDS;DRUM STORAGE REQ.=01728 WORDS;NO. SEGS.=0022.
ESTIMATED CORE STORAGE REQUIREMENT  =  02535 WORDS.
```

## REFERENCES


1. Collins, D. G., Wells, M. B. and Cunningham, K., Light Transport in the Atmosphere, Vol. III: Utilization Instructions for the LITE Codes, Radiation Research Associates, Inc., Report ECOM-00240-1, Vol. III, August 1966.

2. Van de Hulst, Light Scattering by Small Particles, John Wiley and Sons. Inc., New York, N. Y., 1957.

3. Deirmendjian, D. and Clasen, R. J., Light Scattering on Partially Absorbing Homogeneous Spheres of Finite Size, Report for United States Air Force Project Rand R-393-PR, February 1962.

4. Deirmendjian, D., "Scattering and Polarization Properties of Water Clouds and Hazes in the Visible and Infrared," Applied Optics, Vol. 3, No. 2, February 1964, pp. 187-196.

5. Penndorf, R. B., New Tables of Mie Scattering Functions for Spherical Particles, Part 6, Geophysical Research Papers, No. 45, Report AFCRC-TR-56-204(6), Geophysics Research Directorate, Air Force Cambridge Research Center, March 1956.

6. Gumprecht, R. O., and C. M. Sliepcevich, Tables of Light Scattering Functions for Spherical Particles, Ann Arbor, University of Michigan, 1951.

7. Fenn, Dr. R., printout from an NBS code for size parameters ranging from 0.1 to 40 for a refractive index of 1.59 - 0.66i.

UNCLASSIFIED

Security Classification

**DOCUMENT CONTROL DATA - R&D**

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

| | |
|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Radiation Research Associates, Inc.<br>1506 W. Terrell Avenue<br>Fort Worth, Texas 76104 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP<br>N/A |

3. REPORT TITLE

Light Transport in the Atmosphere, Vol. II: Machine Codes for Calculations of Aerosol Scattering and Absorption Coefficients.

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Annual Report, 1 August 1965 to 31 August 1966

5. AUTHOR(S) (Last name, first name, initial)

Cunningham, K., Wells, M.B., and Collins, D.G.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| September 1966 | 128 | 7 |

| | |
|---|---|
| 8a. CONTRACT OR GRANT NO.<br>Contract DA28-043 AMC-00240(E)<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>RRA-T63-2<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>ECOM 00240-1, Vo. II |

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13. ABSTRACT This is the second of three volumes. Volumes I and II contain other aspects of the study: descriptions of the LITE codes and their application to the analysis of experimental data. Two machine programs were developed for use in computing microscopic and macroscopic cross sections for light scattering and absorption by spherical-homogeneous aerosol particles with a complex index of refraction. The first of these programs computes microscopic cross section data by use of the Mie theory. The second program integrates the microscopic cross section data over aerosol particle size distributions to produce macroscipic cross section data. These codes have been written in ALGOL for the Burroughs B-5500 computer and in FORTRAN-IV for other computers.

Calculations obtained from these codes have been compared with data reported by other investigators in order to verify their accuracy. A sizable quantity of aerosol cross section data has been generated for several aerosol particle size distributions and the results are presented in this volume. In addition, a description of the calculational methods and instructions for utilization of the two codes on the B-5500 computer are given to aid those who wish to utilize the codes.

Security Classification

| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
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| Monte Carlo Methods | | | | | | |
| Light Transmission | | | | | | |
| Radiation Transport | | | | | | |
| Variable Air Density | | | | | | |
| Albedo | | | | | | |
| Point Source | | | | | | |
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